• Volume 9G, Number 2–3, August 1960

BULLETIN
OF THE RESEARCH COUNCIL OF ISRAEL

Section G
GEO-SCIENCES

Bull. Res. Counc. of Israel. G. Geo-Sciences

The Weizmann Science Press of Israel • Jerusalem • ירושלים • מוסד ויצמן לפרסומים במדעי הטבע ובטכנולוגיה בישראל

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Dr. Nathan Shalem
(1897—1959)

NATHAN SHALEM — AN APPRECIATION

Dr. NATHAN SHALEM died in Jerusalem on September 19, 1959. With his death, Israeli geology has lost its veteran scientist, one of its most productive workers and, moreover, an unusual and compelling personality.

Dr. SHALEM was born in Saloniki in 1897, the son of an old-established family: his grandfather already acted in that town as rabbi to Jewish sailors. As a youth of 16 NATHAN SHALEM joined the first group of young Saloniki Jews who decided to settle in Palestine. Here he studied at the Jerusalem Jewish Teachers' Seminary, and during the latter years of the First World War he taught school in various villages and later in Jerusalem.

In 1924 SHALEM went to Florence, where he studied natural sciences, particularly geology, and received his Doctor degree. Back in Jerusalem he became a high school theacher, deeply affecting by his enthusiasm for natural sciences generations of students. Not content with the knowledge he had acquired, SHALEM spent several years studying geography at the University of London.

Received May 20, 1960

Late in the forties, Dr. SHALEM felt that the constant burden of teaching put an unbearable strain on his real vocation — scientific research. For several years he worked as a private scholar, giving occasional courses at the Teachers' Seminary. For some time he was external teacher of geography at the Hebrew University in Jerusalem, and a research fellow in its Department of Physical Geography. In 1954 he joined the Geological Survey of Israel as head of the newly formed Department of Quaternary and Geomorphology.

Dr. SHALEM'S scientific interests were broad and manifold, for he set himself the task to study natural phenomena in all their aspects and interrelationships. His first pioneering work was on the geology of the Judean Mountains. For many years he worked in the Judean Desert, which he studied in all its aspects. His many studies, published in numerous papers in Israel and abroad, were devoted to subjects as varied as palaeontology, volcanology, oceanography, gemology, and speleology. His last manuscript, completed just before his death, deals with the salt caves of Mount Sdom.

In all his work SHALEM drew inspiration and direction from the Old Testament, toward which he had a truly scholastic attitude. In his eyes the natural history of Israel was only a prelude to its human history. Hence, his particular interest in the study of the Pleistocene, its land forms and climate, to which he devoted the last years of his life. From here, also, stems his conviction that he could not be bound by the limits of geology, and thus he transgressed into the fields of prehistory, geography, and even Palestinian folklore.

Dr. SHALEM'S particular enthusiasm, however, was devoted to seismology. He built up a network comprising many hundreds of voluntary observers all over Israel, from professional scientists to farmers and bus drivers. The many completed questionnaires received at the Geological Survey after each earthquake in the country constitute one of the best organized and most thorough systems of seismic observation anywhere in the world. Combining his scientific and historical interests, SHALEM compiled an as yet unpublished survey of all earthquakes in the Middle East described or mentioned since biblical times. His published works in the field of seismology comprise macroseismic maps of all the major earthquakes of the Middle East during the last fifteen years, as well as papers dealing with the relationship between seismic and tectonic features of the Middle East and Tsunamis of the Mediterranean.

SHALEM was an extremely hard worker, very modest in his private life, but in his scientific addresses he was an impressive speaker defending his frequently unorthodox opinions with deeply honest conviction. He left many finished and unfinished manuscripts which will now be prepared by his colleagues for publication.

Y. K. BENTOR

REFERENCES

1. SHALEM, NATHAN, 1949, Whitening of the waters of the Dead Sea, *Nature*, **164**.
2. SHALEM, N., 1949, La rosée en Palestine, *La Météorologie*, juillet - sept. 1950, 182-186, Paris.
3. SHALEM, N., 1950, Attributed climatic changes in the Levant, 16*e Cong. Internat. Géographie, Comptes rendus*, 593-649, Lisbonne.
4. SHALEM, N., 1952, La seismicité au Levant, *Research Council of Israel Bull.*, **2**, no. 1, 1-16.
5. SHALEM, N., 1953, La stabilité du climat en Palestine, *Research Council of Israel Special Pub.* no. 2: *Desert Research*, 153-175.
6. SHALEM, N., 1953, The tremor of September 10th, 1953, *Research Council of Israel Bull.*, **3**, no. 3, 266.
7. SHALEM, N., 1953, On the tremor of 28.12.52 in the Galilee and Carmel areas, *Research Council of Israel Bull.*, **2**, no. 4, 438-439.
8. SHALEM, N., 1953, La géographie physique du "Pays d'Israël" dans la littérature hébraïque ancienne, 7*e Cong. Internat. d'Histoire des Sciences Actes*, 571-577, Jerusalem.
9. SHALEM, N., 1953, Sur le karst au Levant, 1*er Cong. Internat. Spéléologie Pubs.*, **2**, sec. 1, 1-14, Paris.
10. SHALEM, N., 1954, Seismicity and Erythrean disturbances in the Levant, *Bur. Central Seismol. Internat. Pubs.*, ser. A, fasc. 19, 267-275.
11. SHALEM, N., 1954, A propos des dernières éruptions volcaniques (aux temps historiques) en Palestine, *Assoc. Internat. Volcanologie Agenda*, p. 11.

12. SHALEM, N., 1954, Seismological research in Israel (report for 1951–1953) *Research Council of Israel Special Pub.*, Jerusalem.
13. SHALEM, N., 1954, The Red Sea and the Erythrean disturbances, 19*e Congr. Géol. Internat.* sec. 15, fasc. 17, 223-231, Algerie.
14. SHALEM, N., 1955, The tremor of 13th September 1954, and the instrumental research from January 1954 – June 1955, *Tahal* (*Water Planning for Israel*) *Ltd.*, & *Geol. Survey of Israel*, Jerusalem, July 1955 (typewritten).
15. SHALEM, N., 1955, Le plateau continental Est-Méditerranéen, *Assoc. Internat. Oceanographie Physique*, *Proc. Verbals* no. 6.
16. SHALEM, N., 1956, Seismic tidal waves (Tsunamis) in the eastern Mediterranean, *Geol. Soc. Israel Bull.*, **3**, (in Hebrew), Jerusalem.

THE PALAEOLITHIC DEPOSITS OF JISR BANĀT YAQŪB

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ABSTRACT

Excavations were carried out in 1936, 1937 and 1951 at Jisr Banāt Yaqūb in the Jordan Valley, south of Lake Hula. The material collected consists of 97 artifacts made of lava (47 hand-axes, 28 cleavers, 2 scraper-like tools and 20 flakes), and of bone tools. Stratigraphic sections of the excavation, as well as description and figures of 12 hand-axes and 11 cleavers are given. The material proves to be of early Acheulean tecnique. However, its exact stratigraphic relation to the Acheulean cultures of Europe is yet uncertain.

INTRODUCTION

During the construction of a bridge over the Jordan River in 1933 the river was made to flow through an artifical channel half a kilometer long and the river bed was drained down to a level of two meters.

Rumours spread through the country that a "fossil giant fish" had been discovered in Galilee.

In April 1933 a heavy box labelled "fossil fish from Lake Huleh" was sent to the President of the Hebrew University, Dr. J. L. Magnes. It contained fragments of an elephant tusk, molars and a few flint flakes. Prof. G. Haas of the Zoology Department was informed that somewhere in Upper Galilee elephant bones had been discovered. Only after inquiries we found out that the fossil bones had been collected near Jisr Banāt Yaqūb on the Syro-Palestine frontier.

A year later Miss D. A. E. Garrod informed the Department of Geology that during a trip to Upper Galilee she and Miss E. W. Gardner had discovered hand-axes of the heaps of debris left on the river bank after completion of the drainage work in 1933 near Jisr Banāt Yaqūb.

During subsequent visits to the site with D. M. A. Bate and L. Picard the heaps of gravels and boulders on both banks of the Jordan were explored and fragments of fossilized bones of mammals and flint artifacts were collected.

Miss D. M. A. Bate who examined the elephant remains believed that they belonged to *Elephas trogontherii* Pohlig, regarded as a distinct Pleistocene fossil.

On one of these trips we picked up from the heaps of gravels a hand-axe made of a lava pebble recorded for the first time in Palestine.

Received March 10, 1960

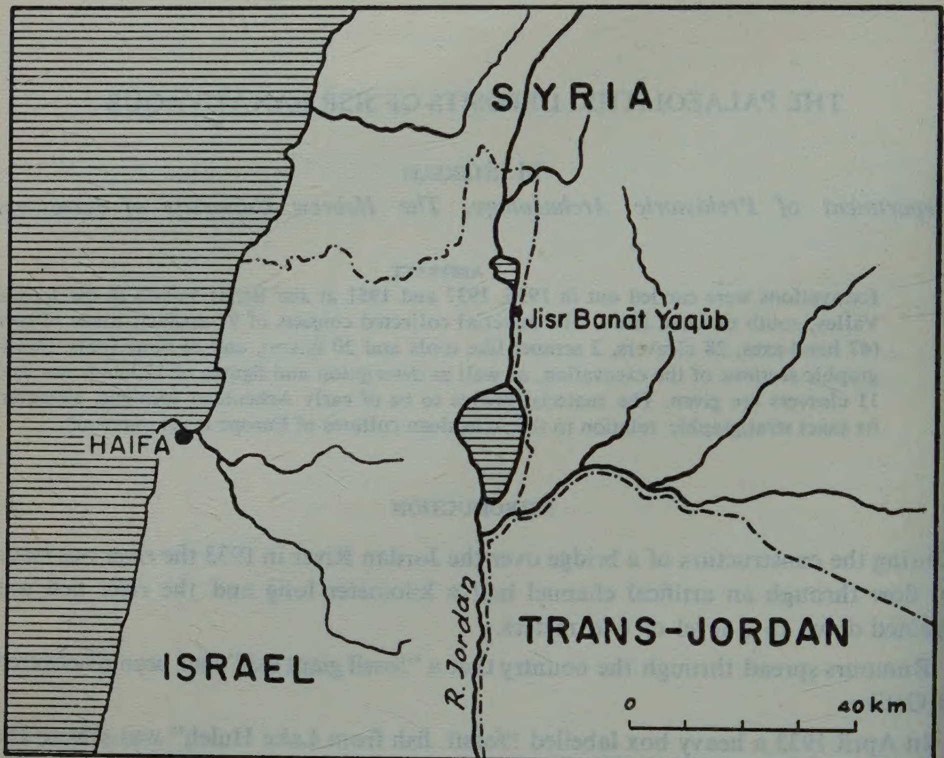

Figure 1
Reference map showing the location of Jisr Banāt Yaqūb

Percolating pit on the left bank of the river

In 1935 when digging a percolating pit for the stables of the Army Mounted Police post on the Syro-Palestine border at Jisr Banāt Yaqūb a layer of fossilized bones was discovered. The author visited the site and found an open square pit 3 m to 3 m and about 4.5 m deep. The author revealed in descending order the following section (fig. 2).

Broken animal bones protruded from the level of green clay. In the debris from the pit fragments of animal bones and teeth with fresh fractures were found. The author was told that some animal bones had been taken by the contractors to Damascus and he was unable to find out what had become of them. It is a great pity that such valuable remains of Pleistocene fauna were entirely lost to science as they never reached a scientific institution either in Palestine nor abroad.

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Arrangements for a geological and archaeological survey were made by the Hebrew University through a grant from its President, Dr. J. L. Magnes. A permit

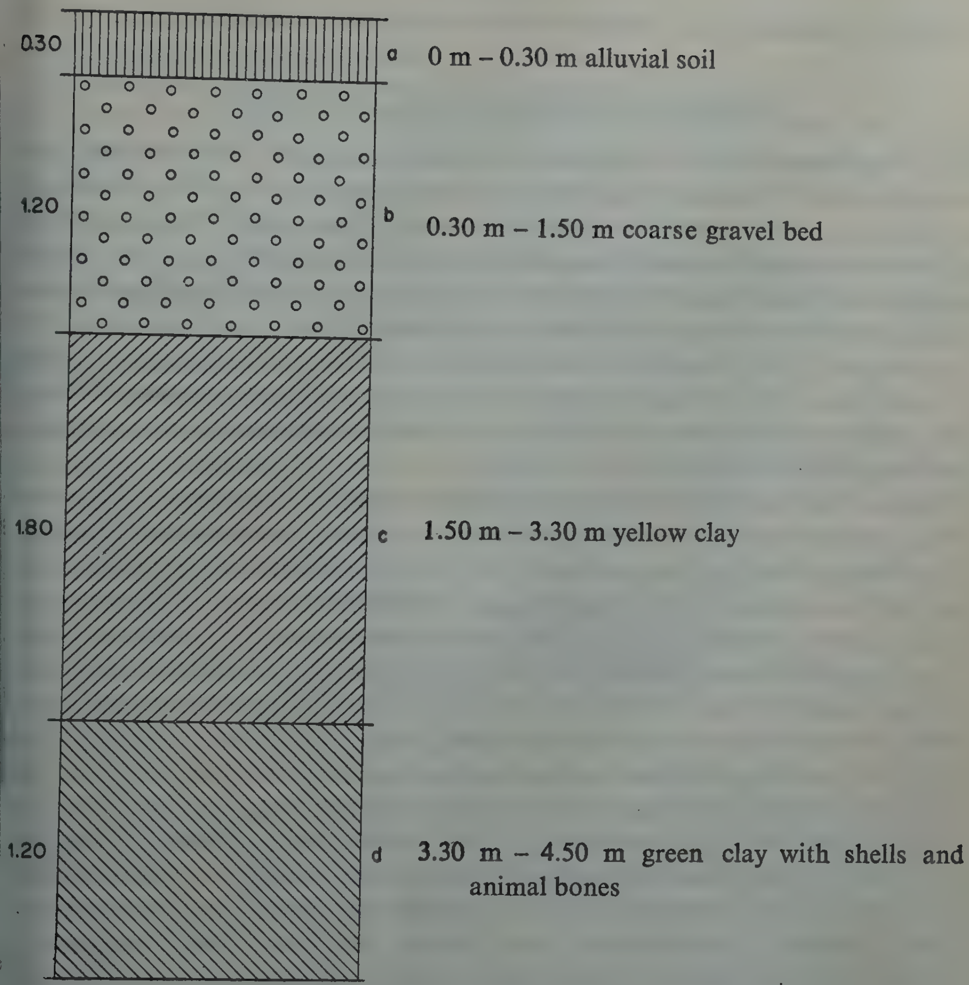


Figure 2

'or archaeological soundings was granted to the author by the Director of Antiquities Department. The site where artifacts and fossil animal bones were discovered is situted about four kilometers south of Lake Huleh, and one and a half kilometers ast of the settlement of Mishmar Ha'Yarden on the Syro-Palestine border.

The main problems were to discover the exact provenance of the stone mplements and faunal remains, to determine the assemblage of artifacts associated vith the layers and to ascertain the relationship of the assemblages to one another.

A difficult problem arose because of the specific conditions of the site when deciding vhere to dig. For many kilometers the banks were mostly covered by heaps of gravel nd mud left there after comletion of the drainage work, and it was out of the question o remove this debris. There was thus little space available for archaeological work.

In these circumstances the problems of archaeological investigations were manifold.

PRELIMINARY EXPLORATION OF THE RIVER BED (1936)

The author began with the investigation of the river bed itself disturbed during the drainage work. In order to do this it was necessary to dam the river by a sluice and taking into account the difference in altitude between Lake Huleh (+70 m) and the Sea of Galilee (–213 m) this method was promising before undertaking any archaeological digging on its banks. Special facilities were afforded by the Palestine Land Development Company and its sluice was kindly put at our disposal.

On March 27, 1936 at midnight the sluice was let down and by 8.30 next morning no more than 0.30 m of water remained in the river and we were able to walk along and explore the river bed and its sections and look for fossilized bones and human artifacts. (Plate I, fig. 2).

The area between the new bridge and the sluice which extends about 3.5 kilometers to the north of the bridge and about 200 m to the south of it was explored. The author considered at that time the river bed to be the lowest layer (α) which was filled with lava boulders, about 0.50 m × 0.50 m and lava and flint pebbles of different sizes. In this area we picked up isolated implements and fragments of fossilized animal bones dispersed all over the river bed. Concentrations of these remains were found in seven localities, four of them to the north of the bridge and three to the south. Three localities situated to the north of the bridge between it and the eucalyptus grove were most interesting. Whether the lava boulders and lava and flint pebbles as well as the concentration of stone implements and fossilized bones were *in situ* or not, was at the time of the explotarion impossible to ascertain. At locality I a fragment of a lower jaw, four molars, fragments of tusks and many splinters of bones all belonging to *Elephas* sp., 5 hand-axes and 8 fllakes of lava rolled and abraded, were found. Locality II was situated about 7 meters north-west where fragments of elephant molars, 12 hand-axes and 8 flakes of lava, all rolled and abraded, were picked up. Locality III was situated 14 meters further north where a fractured and burnt tibia, 100 splinters of bones, mostly burnt, 18 hand-axes and 20 flakes, all made of lava, were found. All these finds were rolled and abraded. All three localities were near the left bank of the river; locality IV was on the right bank. There were found a broken femur, fourteen fragments of ribs a fragment of an atlas, vertebrae mostly broken and rolled, as well as 15 hand-axes, 40 flakes, all of lava and all of them rolled and abraded.

The lava artifacts from these localities were made by "block-on-block" technique and appeared to be of Lower Acheulean type. The author did not consider this assemblage as being discovered *in situ* because of its bad state of preservation and the many fresh fractures on all the artifacts. A flint assemblage, too, was not *in situ* but found in the above mentioned localities, as well as spread all over the river-bed. This assemblage made of grey chert and covered by black or dark brown patina was in a much better

state of preservation, less rolled and abraded, some of the finds had smoothed flake scars and edges, others sharp edges.

The entire flint industry is varied in type, form and technique. It consisted of different cultural assemblages with hand-axes, flakes, fllake-blades, blades, points and cores. Lower, Middle and Upper Palaeolithic technique can easily be recognized. It was obvious that the stone assemblages were derived from other beds disturbed during the drainage of the river.

Three further localities were discovered to the south of the bridge, two of them situated on the right bank and one on the left. Two fragments of fossilized animal bones were picked up (*Equus* and *Cervidae*).The stone artifacts, mostly of chert, were rolled and abraded and covered with a dark brown patina, they belonged to different cultural assemblages and were definitely not *in situ*.

Although the lava and flint industries were not found *in situ*, finding them in their stratigraphical position in the exposed section of the Jordan was of great interest. On the right bank of the river the following section was revealed (fig. 3):

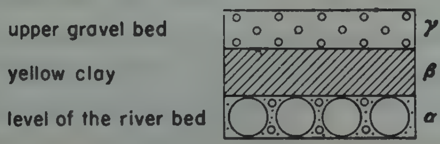


Figure 3

A layer of clay (β) was observed, dark grey (when dry yellowish) bordering on the lowest level of the river bed, (α), its thickness exposed to about half a meter. It included a fauna of fresh-waters hells which according to Picard (1936), "in addition to characteristic forms known from the Sea of Galilee and Lake Huleh, yielded the most interesting genus *Vivipara*, not previously recorded in Pleistocene beds nor in the recent lakes or rivers of Palestine". Fragments of elephant tusks and molars were again noted, as well as bones and teeth of *Cervidae* and *Equidae*. From this layer we picked up eight hand-axes and ten flakes made of grey chert, covered with black patina, and which appeared to be made in Acheulean technique. The flint assemblage was not rolled, and the tools had sharp cutting edges. This layer was covered with water.

Above was a layer of gravel (γ) only partly covered by the Jordan. In this level were twenty flakes made of grey chert, five points, eight flakes with secondary trimming on their edges, and seven flakes without retouch of Levallois technique covered by black patina (figs. 29–31). A bone tool *compresseur* made from a splinter of an animal bone with a pointed tip was found there (fig. 31). Further, three blades and two gravers made of grey chert, highly abraded and covered by brown patina, of Upper Palaeolithic technique were also found. The whole gravel bed was covered by alluvial

debris and soil. It is certain that the above mentioned Upper Palaeolithic blades derived from the alluvial soil. The thickness of the alluvial stratum could not be measured.

EXCAVATIONS IN 1937

After examination of the river bed and its exposed sections field work was resumed in 1937 in a trial pit on the right bank of the Jordan river. The spot selected for excavations was situated about 20 meters to the south of the old bridge. Work was started in March 1937. The author was assisted by P. Solomonica, geologist, and E. Rosenau, topographer. A pit seven meters to North-South and four meters to East-West was dug and the stratigraphy in descending order was as follows (fig. 4):

A. 0 m – 0.42 m. Upper gravel of the old Jordan bed with flint nodules and basalt pebbles of 0.15 m × 0.07 m, a few freshwater shells (*Melanopsis* sp.); twenty flakes and two cores of grey chert of Levallois technique covered with black patina.

B. 0.42 m – 0.60 m. Yellow clay of a transitional zone with small pebbles of 0.05 m × 0.07 m. Among fauna remains were elephant molars, molars of *Equus*, many fractured bones, teeth and antlers of *Cervidae*; some of the fractured bones had been used by man as tools. Ten small pear-shaped and lanceolate hand-axes made of grey chert of Acheulean technique with sharp cutting edges and covered by black patina were found.

C. 0.60 m – 0.92 m. Green clay with a few basalt pebbles and boulders of 0.50 m ×0.50 m. Remains of molars and fractured bones of *Elephas* sp., a fractured molar of *Rhinoceros* sp. Six hand-axes of grey chert of Acheulean technique with sharp cutting edges covered by black patina.

D. 0.92 m – 1.10 m. Lower black soil with limestone and basalt boulders from 0.50 m to 0.60 m diameter. Abundant remains of fresh-water shells (*Melanopsis*, *Vivipara*). Further remains of elephant molars and a complete tusk of an *Elephas trogontherii* (according to D. M. A. Bate) 1.75 m long (Plate I, fig. 1), fractured elephant bones, vertebrae, ribs. Some of the bone splinters had been used as tools. Six hand-axes made of lava, heavily rolled and abraded, and seven hand-axes of grey chert of Acheulean technique with sharp cutting edges covered by black patina were recorded.

At this depth, excavation of the pit was suspended for the following reasons: 1) the bottom of the pit was about two meters below the water level of the river and suffered severely from an influx of water and it became necessary to pump it out during the day; 2) a bank 0.80 m thick only separated the pit from the river, a danger for the team of labourers in case of collapse; 3) the outbreak of riots in Palestine and later the outbreak of the Second World War. Work was thus suspended for many years. But this field work had clearly shown the stratigraphical position of the bone-bearing and implementiferous levels of the Jordan River, and its importance for the study of Old Stone Age man and its culture in Palestine and the entire Near East.

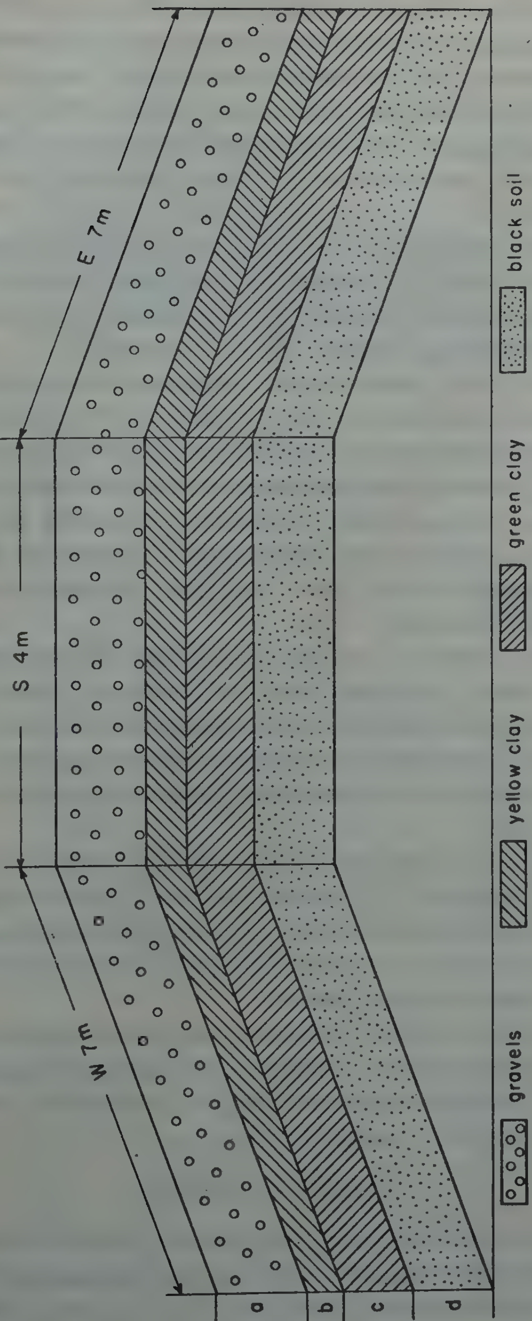


Figure 4

In connection with the Jordan Water Project undertaken by the Israeli Government draining of the Jordan River was begun in 1951. The river bed was excavated more than six meters deep and field work was resumed during subsequent visits to the site. Two more bone-bearing and implementiferous layers were discovered. The author had the opportunity of studying the section, and of extracting fossilized animal bones and stone implements on the spot of the 1937 trial pit. The author could thus complete the study of the sections of the Jordan beds which are in desdending order as follows (fig. 5):

Bed I. 0 m – 0.42 m. Upper gravel of the Old Jordan bed containing flint nodules and basalt pebbles of 0.15 × 0.27 m. Twenty flint implements and three cores of grey chert in Levallois technique were recorded. The implements had a sharp working edge and were covered with black patina. (figs. 29, 30 and 32).

Bed II. 0.42 m – 0.60 m. Yellow clay of transitional zone with basalt pebbles 0.05 m × 0.07 m. Molars and broken bones of *Equus* sp. Five small pear-shaped and lanceolate hand-axes made of grey chert and covered with black patina. The implements have sharp working edges and appear to be of Micoquian technique.

Bed III. 0.60 m – 0.90 m. Green clay with a few basalt pebbles and boulders of 0.40 m × 0.42 m. Fragments of elephant and rhinoceros molars were recorded, as well as two hand-axes of grey chert with sharp cutting edges and two primary flakes of Acheulean technique.

Bed IV. 0.90 m – 1.70 m. A thick bed of black soil with limestone, flint, and basalt pebbles and boulders. Abundant fauna of mollusca *Melanopsis* and *Vivipara* (in the same level a tusk of a young *Elephas trongontherii* 1.75 m in length had been found in 1937). Three hand-axes of lava, rolled and abraded, were found. In addition five hand-axes of grey chert, not rolled, with sharp cutting edges, covered with black patina, were recorded.

Bed V. 1.70 m – 3.40 m. Hardened black soil with abundant mollusca *Melanopsis* and *Vivipara* and fragments of fossilized bones of *Elephas* and other animals, and a very rich lava industry, neither rolled nor abraded, with sharp cutting edges was recorded. The stone industry appeared to be of an early Acheulean technique and included flaked hand-axes and cleavers.

Bed VI. 3.40 m – 5.50 m. Thick gravel bed with flint, limestone, lava pebbles and boulders with heavily rolled and abraded artifacts (hand-axes and cleavers). The flake scars were abraded in such a way that it was difficult to recognize them; only their shape and the S-twist reminded of hand-axes.

THE STONE INDUSTRY

Raw material: The surrounding area of the Jordan Valley is rich in raw material of good quality as flint, chert and lava. In the upper layers (beds I-IV) flint or chert was used for artifacts. Some lava artifacts found in these levels were rolled and abraded and the author considered them as being in a secondary deposit and not *in situ*. The specimens from the lower layer (bed V) are made of lava pebbles or lumps of lava.

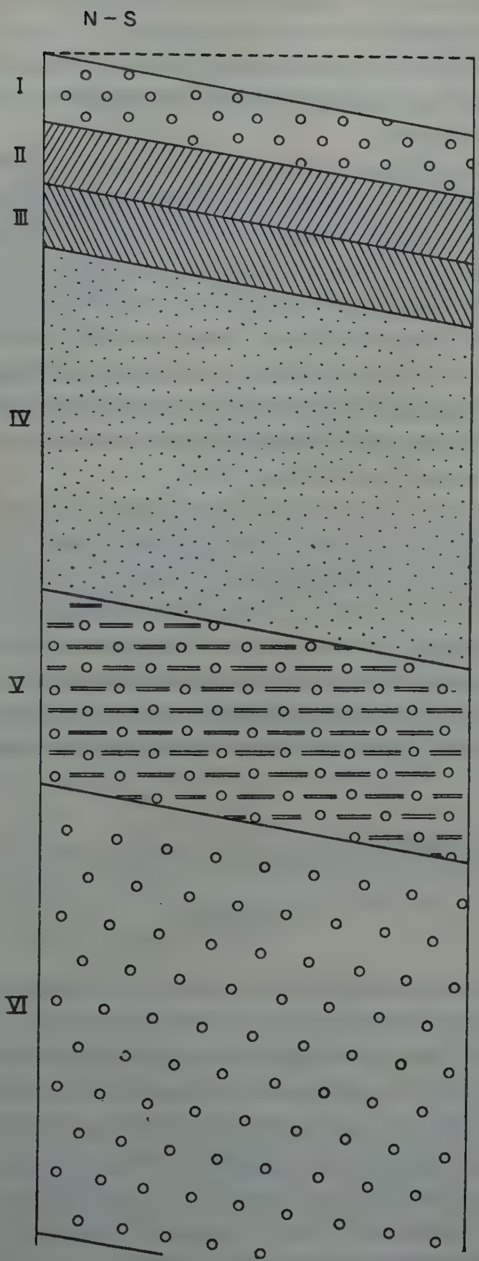


Figure 5

The raw material was derived from the Jordan Valley and was exposed on the banks of the river in the days when early palaeolithic man lived there. The implements are very sharp and were not exposed to atmospheric conditions for a prolonged period before being covered by bed IV.

The artifacts of lava: Artifacts were represented by bifaces (hand-axes), cleavers and rough flakes. They were obtained either from pebbles or from lumps of lava, by "block-on-block" technique.

Hand-axes: The entire surface of the hand-axes made of pebbles was trimmed on both faces and care was taken to produce a cutting edge along both sides and a rough tip. On some of the specimens the base retained the natural face of the pebble, on others extended around it; in their sections they are biconvex and the edges have a S-line twist. Hand-axes on flakes were made of lumps of lava. One face was flat, the other trimmed all over by large flaking. Sometimes the flaking extends around the base or on the edges of the flat surface. The sections were planoconvex; the striking platforms thick and broad were thinned by chipping. The edges were straight and sharp. The following shapes were among the hand-axes: almond, pointed almond, piriform, limande, various (Plate II, figs. 1, 2).

Cleavers: The cleavers were made of flakes from lumps of lava by "block-on-block" technique. The striking platforms were broad and thick, and percussion was used for the thinning or removal of it. The cutting edge which is never trimmed is, however, sharp and straight, convex or oblique. Some of the cleavers are markedly U-shaped in form, others are rectangular. Their sections are rectangular, planoconvex or parallelograms. The predominating side-struck cleavers are the most characteristic type.

Flakes: Twenty flakes of lava from 114 mm to 157 mm in lenght mostly with markedly obtuse angles of the striking platforms were recorded. No special comments.

DESCRIPTION OF IMPLEMENTS MADE OF LAVA

A. Hand-Axes

No. 1. Made of a lava pebble. Greatest length 130 mm, greatest width 92 mm, greatest thickness 44 mm. Both faces have been regularly flaked. The butt end itself and one third of both faces of the implement consist of the original pebble surface. At the top end two sharp cutting edges are joined to each other by a transverse cutting edge. The cutting edges of the biface are sharp; the cross-section is biconvex (fig. 6).
No. 2. Made of a lava flake. Greatest length 180 mm, greatest width 100 mm, greatest thickness 57 mm. Both sides have been regularly trimmed all over and around the butt end, the cutting edges are sharp and show a tendency towards an "S-twist". The cross-section is biconvex. The specimen has a pear-shaped outline (fig. 7).
No. 3. Made of a lump of lava. Greatest length 298 mm, greatest width 110 mm, greatest thickness 51 mm. This is a truly magnificent specimen and has a pear-shaped

outline. It is trimmed all over both faces and has sharp cutting edges including the butt end. The cross-section is thin oval (fig. 8).

No. 4. Made of a lava pebble. Greatest length 185 mm, greatest width 145 mm, greatest thickness 55 mm. The specimen is trimmed all over both faces and around the butt end. On one face a patch of the original surface of the pebble is retained. The cutting edges are sharp. The general outline is pear-shaped and the cross-section is biconvex (fig. 9).

No. 5. Made of a lump of lava. Greatest length 257 mm, greatest width 113 mm, greatest thickness 58 mm. This is a fine specimen of limande outline and is trimmed all over including the butt end. The lower face is flat and the cross-section is plano-convex. The specimen is slightly abraded, but all the flake scars are clear and the cutting edges are sharp (fig. 10).

No. 6. Made of lava flake. Greatest lenght 185 mm, greatest width 145 mm, greatest thickness 35 mm. The upper face flaked all over is convex, the lower one is flat with secondary flaking round one edge. The cutting edges are sharp. The cross-section is planoconvex (fig. 11).

No. 7. Made of a lava flake. Greatest length 192 mm, greatest width 124 mm, greatest thickness 45 mm. This is a fine specimen of limande outline with a sharp cutting edges. Both faces are trimmed all over including the butt end. The cross-section is planoconvex (fig. 12).

No. 8. Made on a side-struck lava flake. Greatest length 152 mm, greatest width 92 mm, greatest thickness 47 mm. The upper surface is trimmed all over and is convex, the lower one is flat with secondary flaking round one edge; the striking platform removed by flaking in order to make a sharp cutting edge (fig. 13).

No. 9. Made of a lump of lava. Greatest length 161 mm, greatest width 112 mm, greatest thickness 67 mm. The specimen has been flaked all over both faces; the sharp cutting edges converge to a point (broken). The cross-section is trapezoid. It appears to have had a pear-shaped outline (fig. 14).

No. 10. Made of a lump of lava. Greatest length 160 mm, greatest width 92mm, greatest thickness 44 mm. The specimen has been trimmed all over both faces and round the butt end. The cutting edges are sharp, as well as the butt end; the top end is transverse but such as to justify the description as "cleaver" (fig. 15).

No. 11. Made of a lump of lava. Greatest length 142 mm, greatest width 92 mm, greatest thickness 52 mm. This is a fine specimen of almond outline trimmed on both faces. The edges are sharp and show a tendency towards an "S-twist". The cross–section is biconvex (fig. 16).

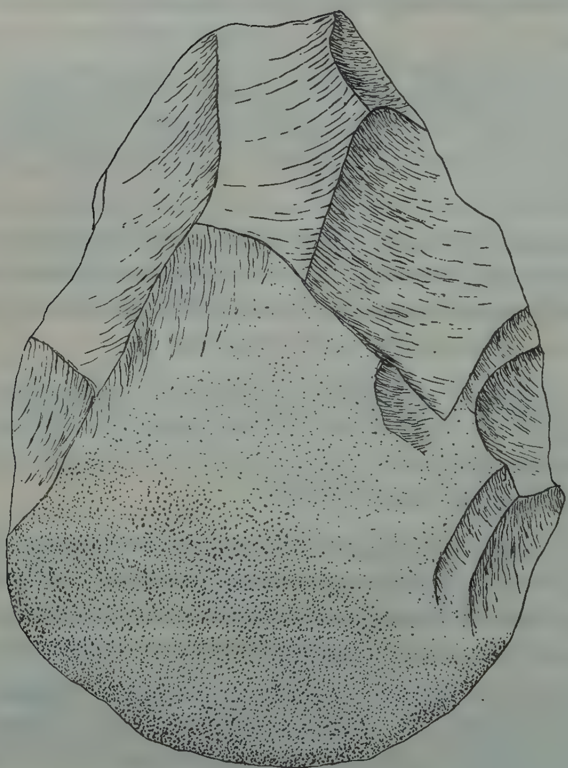
No. 12. Made of a lump of lava. Greatest length 140 mm, greatest width 96 mm, greatest thickness 37 mm. The specimen is almond in outline and trimmed on

both faces, the cutting edges are sharp; they show a tendency towards an "S-twist". The cross-section is less biconvex (fig. 17).

HAND-AXES

Figures 6–17

(The magnifications were approximated to the nearest hundredth)



× 0.77

Figure 6

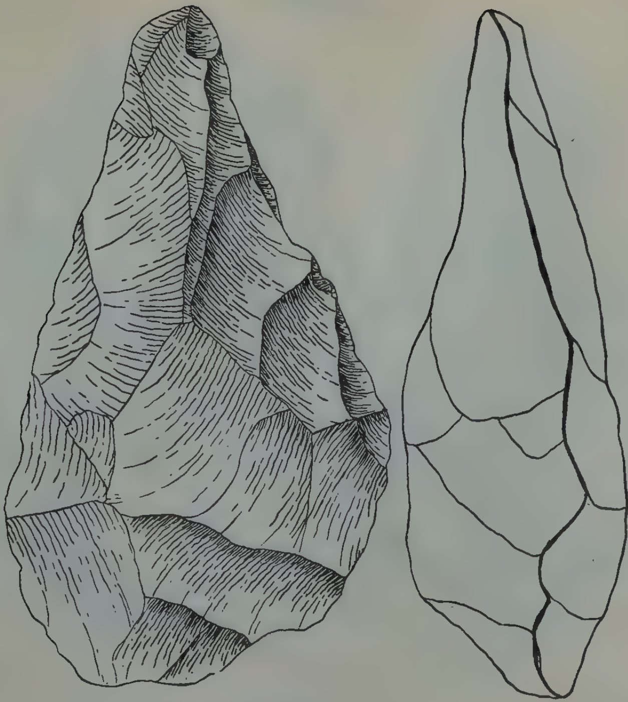


Figure 7 × 0.50

Figure 8 × 0.33

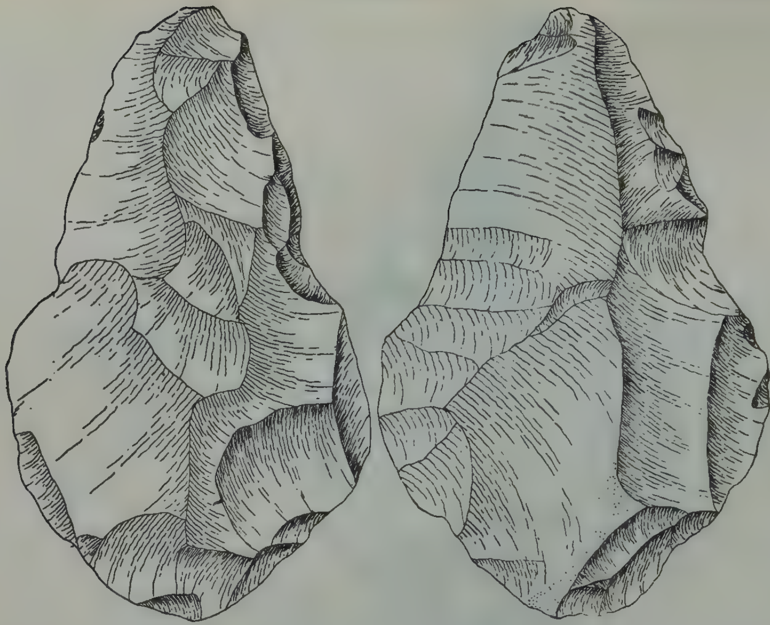


Figure 9 × 0.44

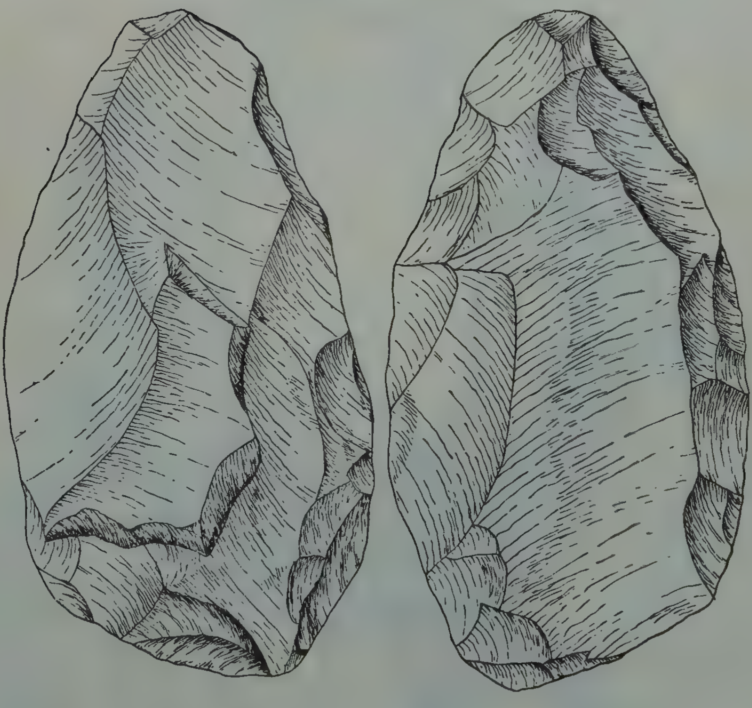


Figure 10 × 0.35

Figure 11 × 0.47

Figure 12 × 0.46

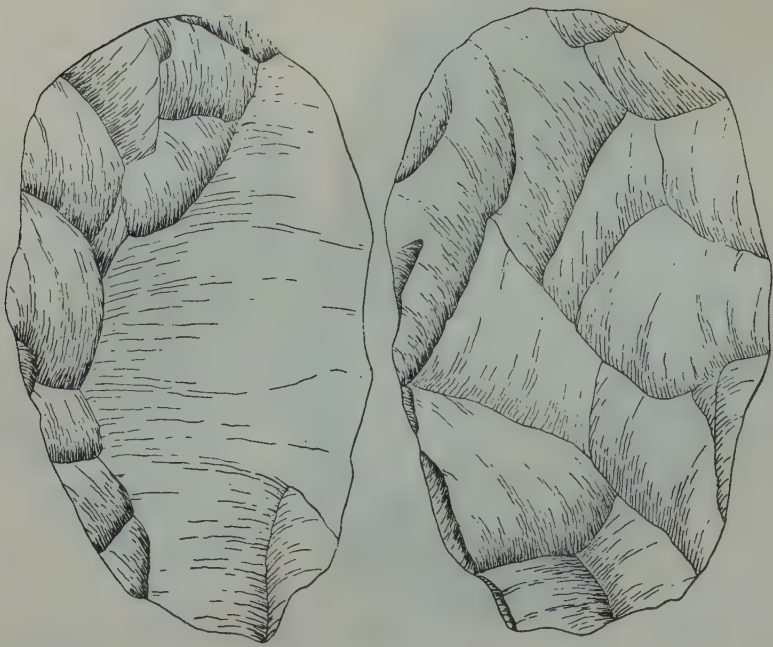


Figure 13 × 0.55

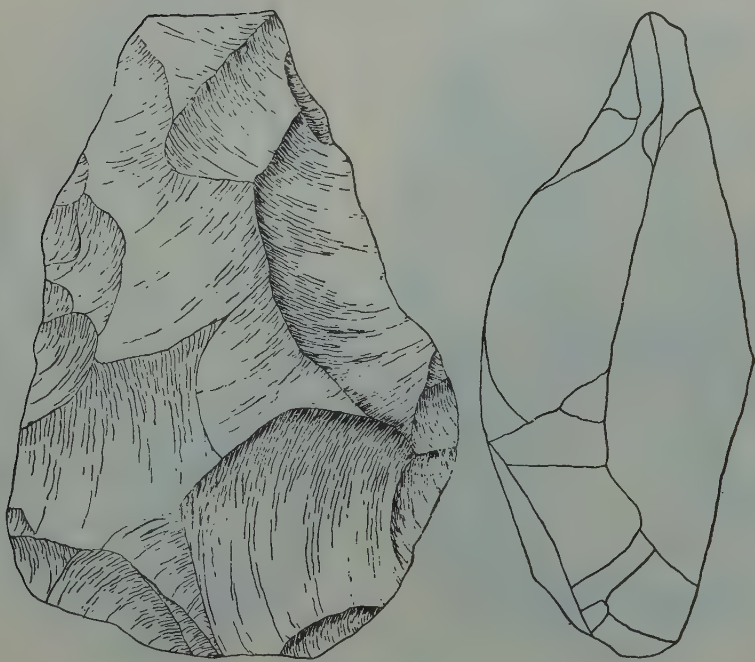


Figure 14 × 0.53

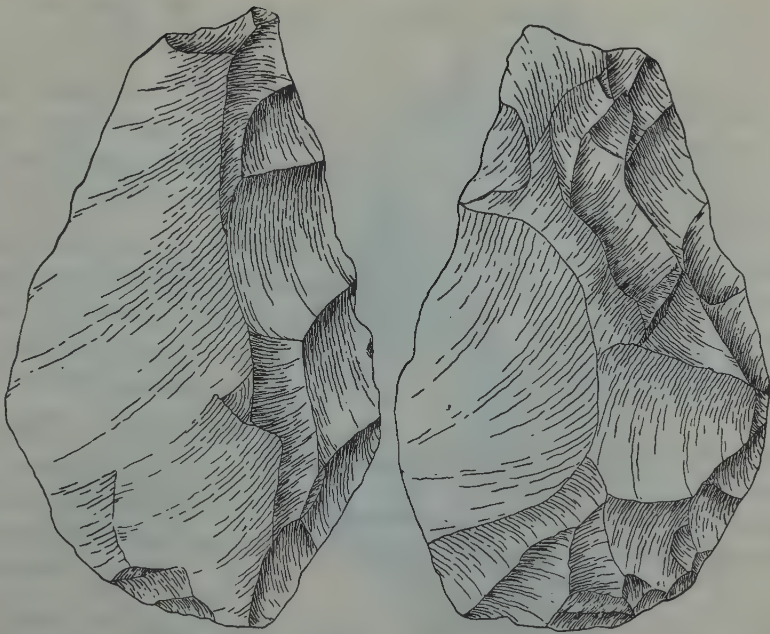


Figure 15 × 0.51

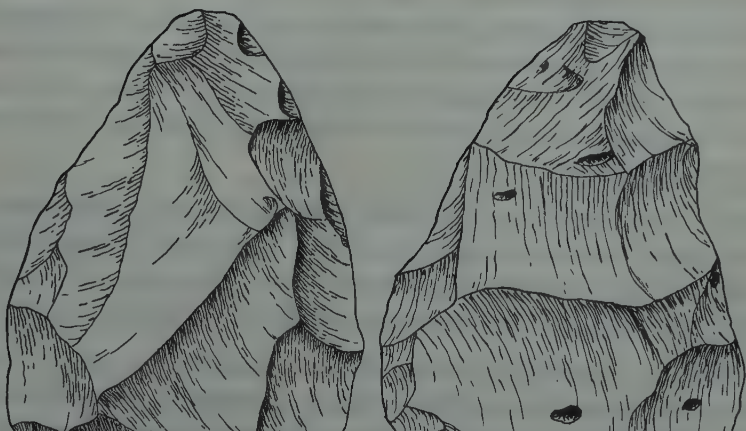


Figure 16 × 0.50

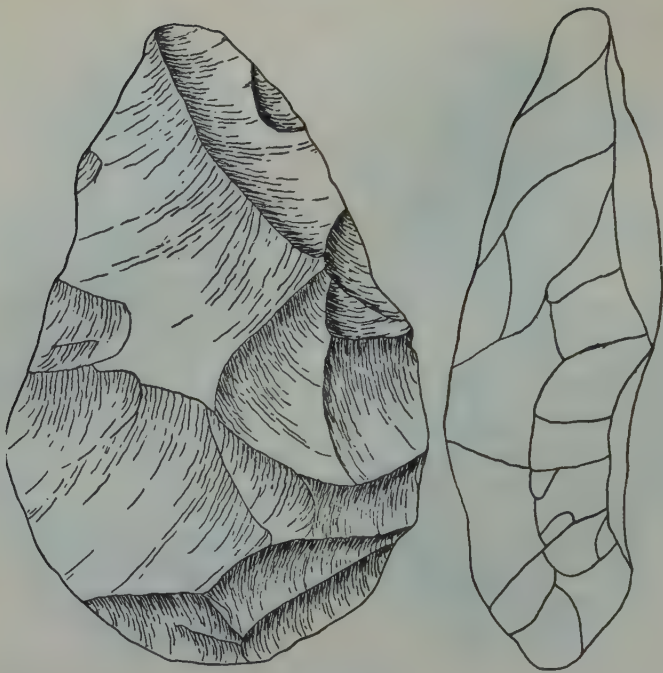


Figure 17 × 0.60

B. Cleavers

No. 13. Made of a large flake of lava. Greatest lenght 160 mm, greatest widt 95 mm. greatest thickness 45 mm. This specimen has been trimmed on one face, th other remaining flat, while the side-striking platform was removed by secondar flaking to make a sharp cutting edge. The butt end is sharp and rounded in outline the working edge on the top end is sharp and more or less straight. The cross-sectio near the butt end is planoconvex (fig. 18).

No. 14. Made of a large flake of lava. Greatest length 128 mm, greatest width 90 mr greatest thickness 43 mm. This is a fine specimen more or less U-shaped in outline partly trimmed on both faces near the butt end. The working edge on the top is shar and more or less straight. The cross-section near the butt end is planoconvex (fig. 19

No. 15. Made of a large flake of lava. Greatest length 161 mm, greatest width 11 mm, greatest thickness 39 mm. The specimen is trimmed on one face and bot sides of the other. The cutting edge on the top end is oblique and sharp. The cross section is planoconvex (fig. 20).

No. 16. Made of an end struck large flake. Greatest length 140 mm, greatest widt 120 mm, greatest thickness 35 mm. The specimen is flaked on one face, on the othe one only on the sides; they converge towards the butt end which is rounded in outlin

The cutting edge at the top is sharp and oblique. The cross-section near the butt end is planoconvex (fig. 21).

No. 17. Made of a large flake of lava. Greatest length 135 mm, greatest width 104 mm. greatest thickness 29 mm. Thc sides of this cleaver are more or less parallel instead of being convergent. The cutting edge at the top end is sharp and straight. This cleaver shows a parallelogram section and is quadrangular in outline (fig. 22).

No. 18. Made of a flake of lava. Greatest length 120 mm, greatest width 83 mm, greatest thickness 32 mm. The lower surface is flat with some secondary flaking round one edge. The sides converge slightly towards the butt end which is rounded. The cutting edge at the top of the tool is slightly convex and sharp. The specimen is more or less U-shaped in outline. (fig. 23).

No. 19. Made of a flake of lava. Greatest length 127 mm, greatest width 85 mm, greatest thickness 45 mm. The upper face is flaked, the lower surface is flat with secondary flaking round the edges. The sides converge slightly towards the butt end. The cutting edge at the end of the tool is sharp and slightly oblique. The cross-section is planoconvex (fig. 24).

No. 20. Made of a large flake of lava. Greatest length 145 mm, greatest width 102 mm, greatest thickness 40 mm. This is a nice cleaver trimmed on one face; the butt end is round, the cutting edge at the end of the tool is sharp and slightly concave. The striking platform was removed by secondary flaking. The cross-section is planoconvex (fig. 25).

No. 21. Made of a lump of lava. Greatest length 140 mm, greatest width 105 mm, greatest thickness 45 mm. The specimen is trimmed on both faces; the butt end is round and the cutting edge at the end of the tool is sharp, more or less straight. Part of it is broken off, probably as a result of use (on the right side). The cross-section through the middle of the implement is biconvex (fig. 26).

No. 22. Made of a flake of lava. Gratest length 175 mm, greatest width 110 mm, greatest thickness 45 mm. The upper surface trimmed all over, the lower face is flat with secondary flaking round one edge. The cross-section is planoconvex. The cutting edge at the end of the tool is oblique and sharp. Typologically this fine specimen is closer to a cleaver or large flake scraper than to a hand-axe (fig. 27).

No. 23. Made of a large flake of lava. Greatest length 168 mm, greatest width 114mm, grcatest thickness 45 mm. Oval in shape, thc lower surface is flat, the uppcr one is flaked. Thc striking platform was thinncd by secondary flaking. The cross-section is planoconvex. This specimen seems more to be a scraper than a "cleaver" (fig. 28).

We will discuss the lavä artifacts recovered and definitely marked for position in strata. Of the total of 97 specimens recorded forty-seven are hand-axes on lava pebbles or flakes, twenty eight cleavers, two scraper-like tools and twenty flakes.

The length in centimeters of forty·seven hand-axes and twenty-eight cleavers is as follows:

CLEAVERS

Length	9–10	10–11	11–12	12–13	13–14	14–15	15–16	16–17	17–18	over 18
Hand-axes	1	—	5	6	3	12	12	5	—	3
Cleavers	—	—	—	4	6	10	3	3	2	—

Thc lava artifacts are obviously of an early Acheulean technique and block-on-block technique was used.

Figures 18–28

(The magnifications were approximated to the nearest hundredth)

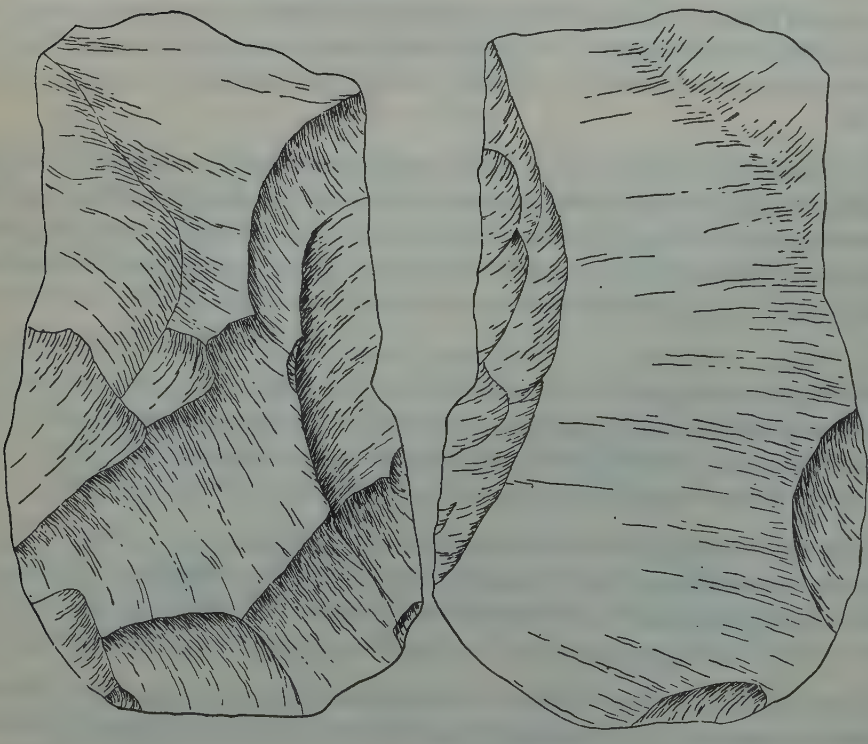


Figure 18 × 0.58

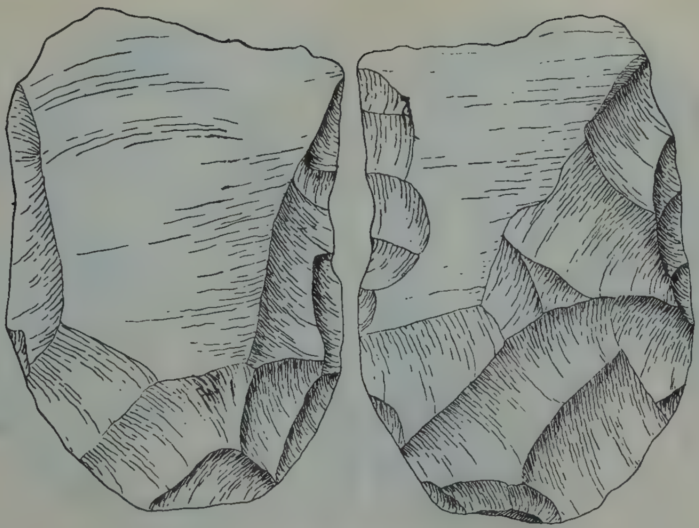


Figure 19 × 0.52

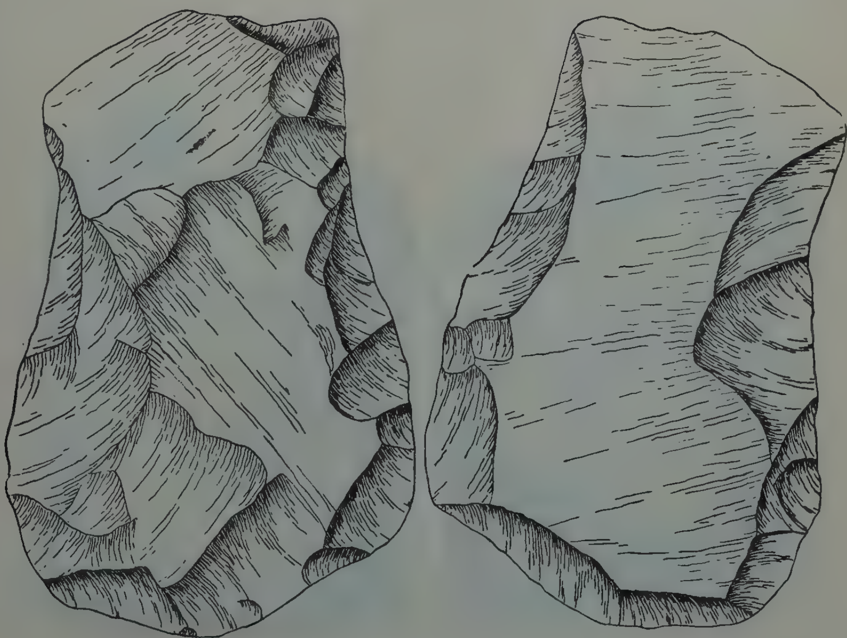


Figure 20 × 0.51

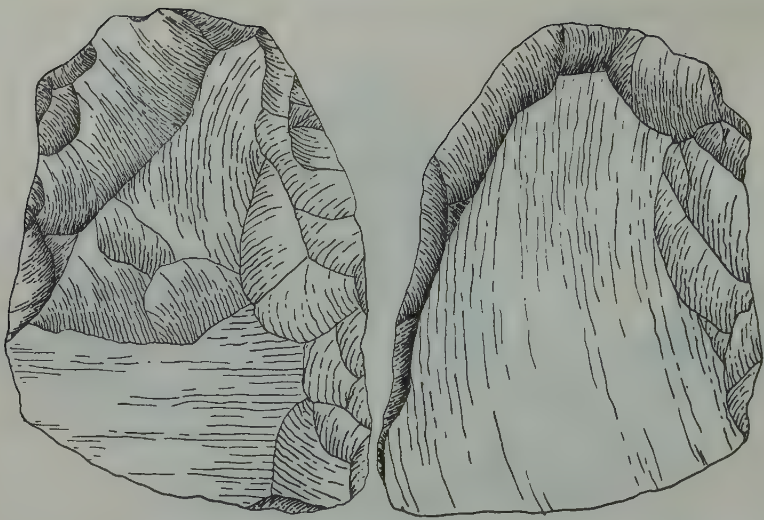


Figure 21 × 0.49

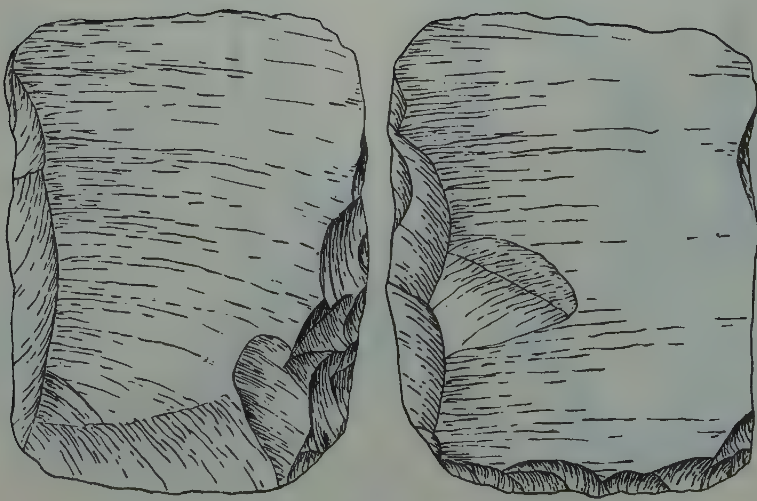


Figure 22 × 0.48

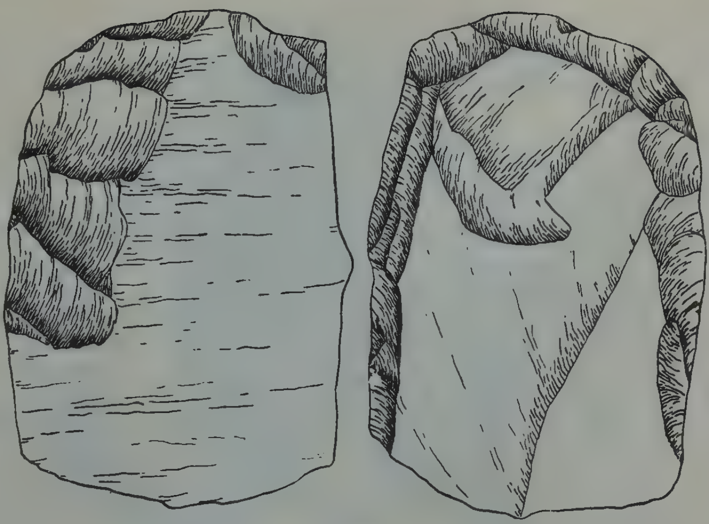


Figure 23 × 0.55

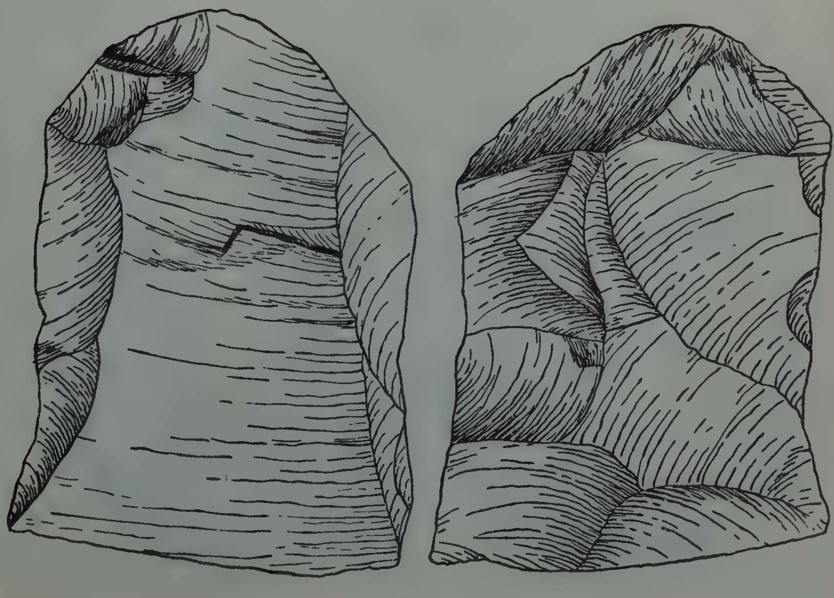


Figure 24 × 0.59

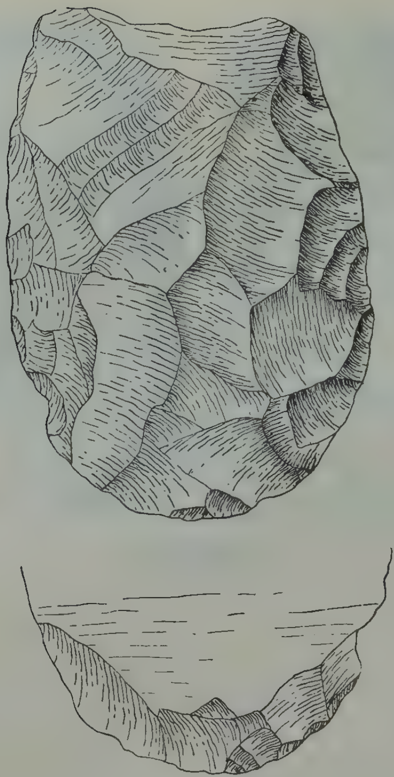


Figure 25 × 0.54

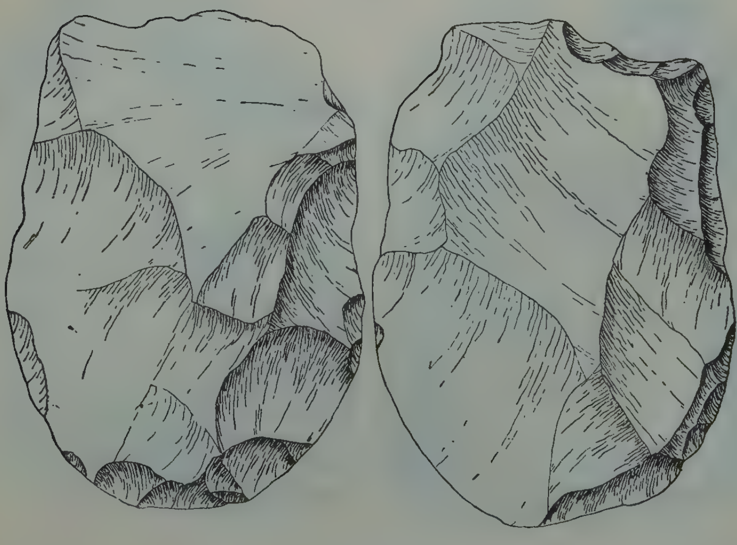


Figure 26 × 0.48

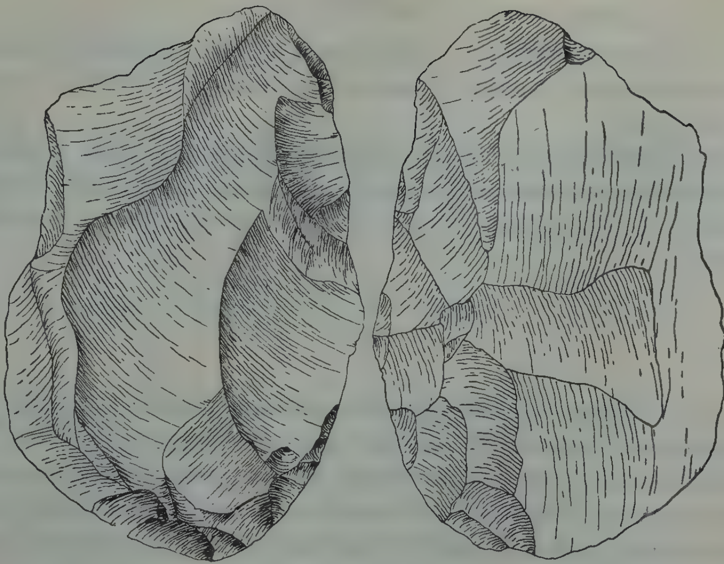


Figure 27 × 0.42

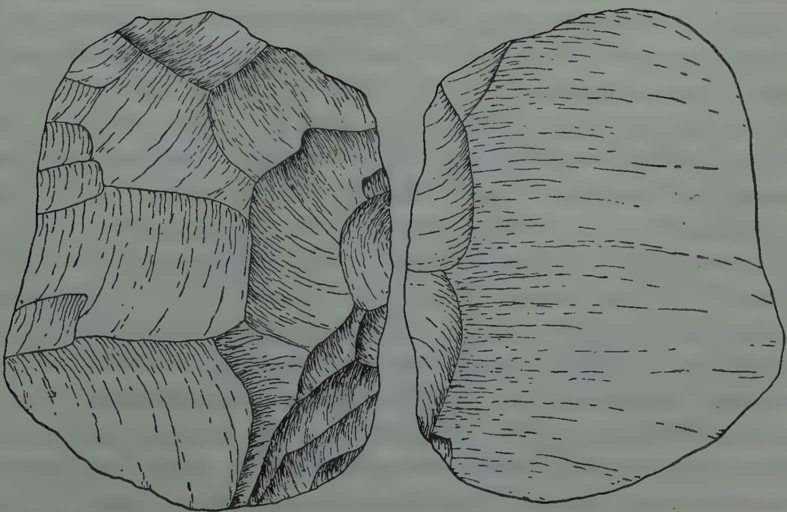


Figure 28 × 0.37

C. *Bone tools*

What is particular to this site is that some of the fractured elephant limb bones have been used as tools. All the tools recorded bear marks of bruising and show traces of use.

One fractured limb bone, 0.35 m long, 0.07 m wide, 0.07 m thick, was found at the junction of Beds III and IV was and probably used as a hammer for manufacturing flint implements. It is very handsome for such a work and shows marks of bruising on one edge.

* * *

In this paper the author describes the field work carried out in 1936, 1937 and 1951.

This work revealed for the first time bone bearing and implementiferous layers in the Jordan Valley. As these layers were recovered in their stratigraphical position, it must be pointed out that this site is of considerable importance as early palaeolithic stone assemblages were previously known in Palestine fron surface finds only.The Jisr Banāt Yaqūb site yielded first-hand documentation of great value for the chronology of the Pleistocene of Palestine and of the Near East. From this point of view the site presents unique features where archaeological, geological and palaeontological correlation is possible. This site has of course not solved all problems concerning Pleistocene geology and archaeology and correlation between them but rather raised numerous new problems. Our knowledge of the Pleistocene of Palestine is at present so poor as to render an attempt at correlation of no great value.We have more geological observations than systematic research in the Pleistocene deposits made in close collaboration with archaelogy, and Jisr Banāt Yaqūb is the first site where such an attempt was made. At the first glance at the assemblage of Jisr Banāt Yaqūb the lava bifaces typify those of the European Acheulean; it is, however, clear that they cannot be compared with the Acheulean industry of Europe. The term "Acheulean" is used here as a purely technical one and not as a cultural or stratigraphical term. One of the problems arising is the relation of the Jisr Banāt Yaqūb assemblage to others known from finds in Palestine. Our knowledge of early Palaeolithic industries from the Near East recovered *in situ* is limited to deposits from two caves (Umm-Qatafa in the Judean Desert, and Mugharet et-Tabun on Mount Carmel) in Palestine and from a terrace at Bahsah near Tripoli in Lebanon. From these site very poor flake industries were recovered labelled "Tayacian" and very little is known about them. The overlying flint assemblages (Umm-Qatafa, et-Tabun) labelled "Acheulean" are of the most advanced technique, even those of layer E (Umm-Qatafa) which was considered by R. Neuville (1951) to be "Middle Acheulean". The author believes, therefore, that a considerable gap exists between the early Palaeolithic assemblage of Jisr Banāt Yaqūb and the oldest known from the caves. The hope is that further research will be able to fill the existing gap.

REFERENCES

1. Neuville, R., 1951, Le Paléolithique et Mésolithique du désert de Judée, *Inst. Paléontologie Humaine Archives*, **24**, 270.
2. Picard, L., 1943, *Structure and evolution of Palestine*, Jerusalem, 134 pp.
3. Picard, L., 1952, The Pleistocene peat of Lake Hula, *Geol. Inst. Pub.* no. 3, 147-156, Jerusalem.
4. Stekelis, M., 1954, The implementiferous beds of the Jordan Valley, *IV Cong. Internat. de Ciencias Prehist. y Protohist. Crónica.*, pp. 391-394, Madrid.
5. Stekelis, M., and Picard, L., 1936., Jisr Banāt Yaqūb, *Palestine Dept. Antiquities Quart.*, **6**, 214-215, and **7**, 45.

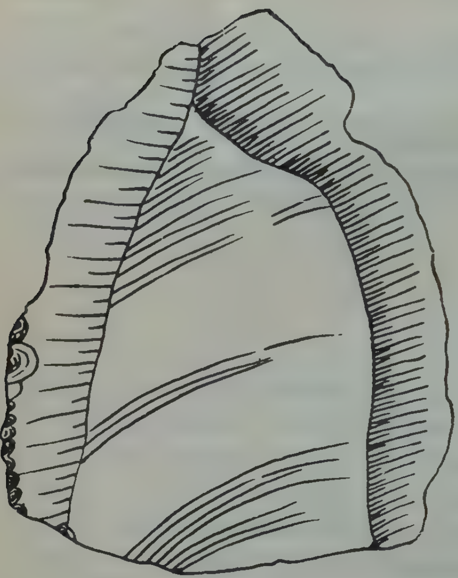


Figure 29

Figure 31

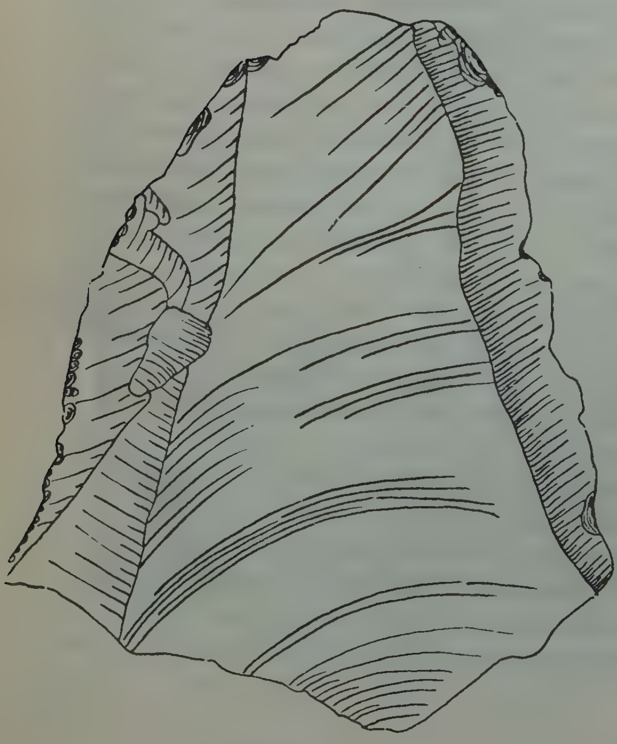


Figure 30

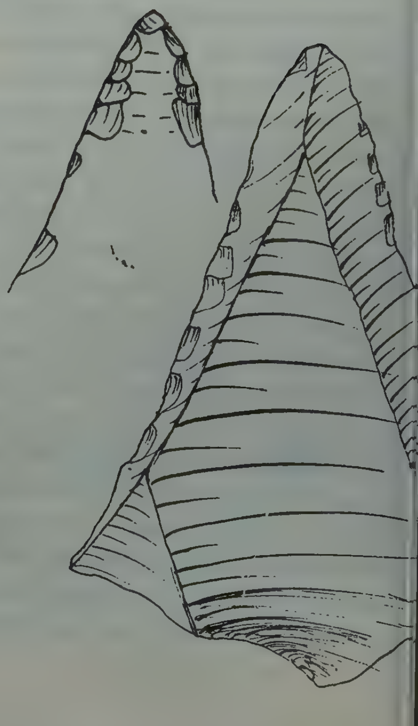


Figure 32

PLATE I

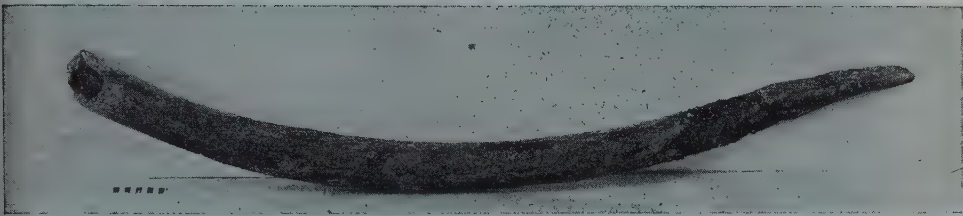


Figure 1

A tusk of *Elephas trogontherii* Pohlig. *ca.* × 0.06.

Figure 2

The Jordan River bed. The site of exploration in 1936.

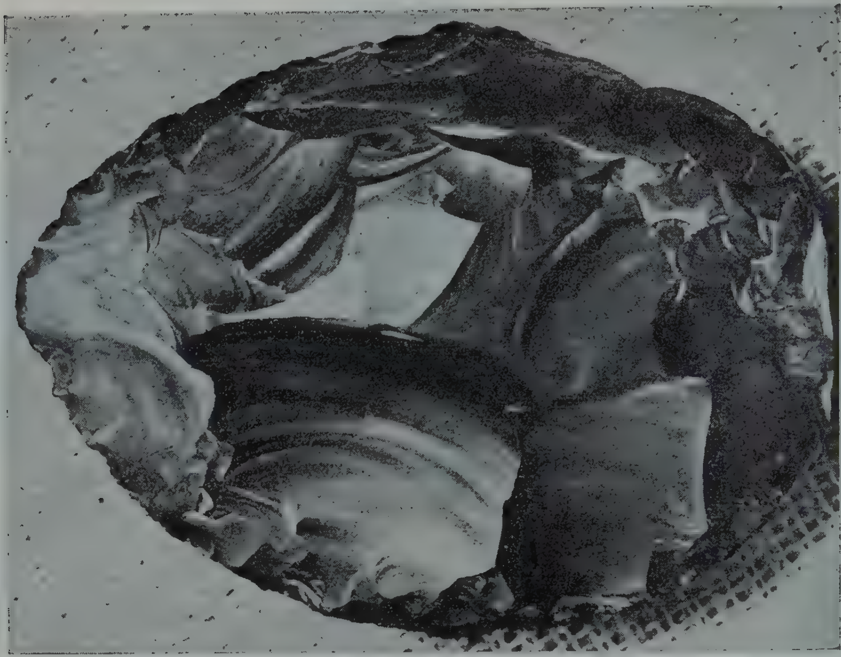


Figure 1
Ovate hand-axe made from grey chert. Patina black. The implement was flaked on both faces with
woden striker. The edges are sharp. Biconvex in cross-section.

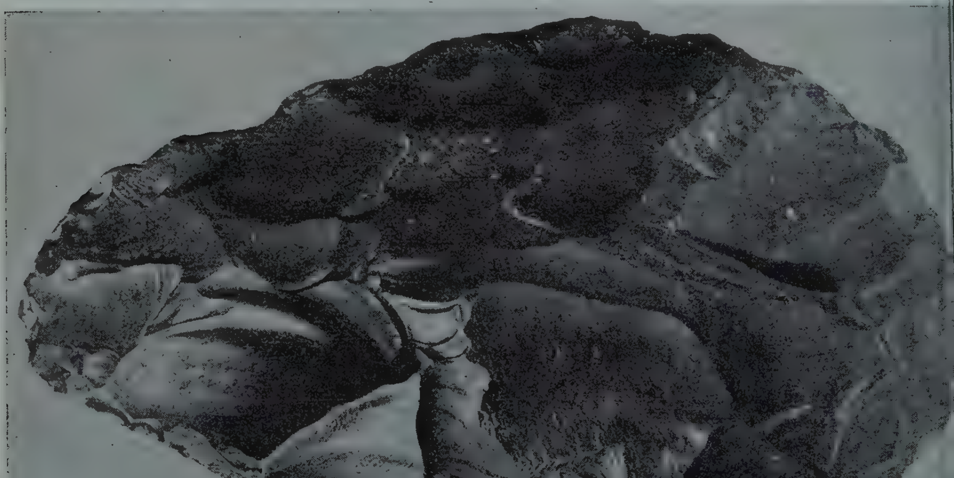


Figure 2
Hand-axe of *limande* type, from grey chert. Flaked on both faces with a wooden striker the edg
are sharp. The butt end is sharp and trimmed all over. Biconvex in the cross-section. The impleme
is covered by black-patina.

LE PRÉ-AURIGNACIEN DE YABROUD (SYRIE), ET SON INCIDENCE SUR LA CHRONOLOGIE DU QUATERNAIRE EN MOYEN ORIENT

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RÉSUMÉ

D'un examen statistique des séries recueillies par le Dr. Rust à Yabroud (Syrie) il découle qu'il existe bien à Yabroud, sous plusieurs couches moustériennes, une industrie nettement de type Paléolithique supérieur. Ceci nous amène à mettre en question la chronologie habituellement acceptée pour le Moyen Orient. Comme ce Pré-Aurignacien ne saurait être bien plus ancien que le Paléolithique supérieur occidental, il semble qu'il faille rajeunir presque tout le Paléolithique du Moyen Orient. En particulier une partie du Moustérien serait contemporaine du Paléolithique supérieur européen.

Dans les trente dernières années, le Moyen Orient s'est signalé à l'attention des géologues du Quaternaire et des préhistoriens par une série de travaux et de découvertes de première importance: travaux de L. Picard, fouilles de Miss Garrod au Mont Carmel, de Neuville et Stekelis au Djebel Kafzeh, de Neuville à Oum-Qatafa, Abou-Sif, etc, d'A. Rust à Yabroud (Syrie), pour n'en citer que quelques-uns. Ces découvertes, comme il arrive souvent, ont posé plus de nouveaux problèmes qu'elles n'en ont éclairés d'anciens, et les corrélations entre le Quaternaire du Moyen-Orient et celui de l'Europe occidentale sont encore loin d'êtres claires. Le problème ne peut être résolu qu'en l'attaquant de plusieurs côtés à la fois, et le point de vue que nous allons exposer, qui peut sembler à première vue purement typologique, aura, s'il se révèle correspondre à la vérité, des répercussions considérables sur la chronologie du Paléolithique, et, en conséquence, du Quaternaire du Moyen Orient.

Parmi les gisements préhistoriques, les trois abris sous roche de Yabroud, près de Damas (Syrie), nous semblent particulièrement importants. Ils ont été fouillés par le Dr. A. Rust, bien connu par ses beaux travaux sur le Paléolithique et Mésolithique des environs de Hambourg.

Dans l'abri I, Rust ne distingua pas moins de 25 niveaux archéologiques, auxquels il donna des noms variés et provisoires, dont certains seront probablement à abandonner. Grâce à l'amabilité du Dr. Rust, nous avons pu examiner en détail, en 1954, les industries de l'abri I de Yabroud, ainsi que celles de l'abri II, en utilisant notre méthode d'étude statistique (Bordes et Bourgon 1951). Nous ne referons pas ici l'étude typologique détaillée de ces industries, car ce n'est pas le lieu de le faire, et nous avons

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déjà publié nos conclusions (Bordes 1955), mais nous essayerons de mettre en évidence les problèmes de chronologie posés par la stratigraphie de Yabroud.

Stratigraphie de Yabroud:

Dans le remplissage de l'abri I, épais d'environ 11 m (Rust 1950), le Dr. Rust distingua quatre grandes divisions géologiques. De haut en bas: Niveau A, allant de la surface à – 2 m, éboulis calcaires avec éléments fins mélés, et avec, en surface, les restes d'une couche concrétionnée et à la base une couche à demi-durcie. Couches archéologiques 1 à 9. — Niveau B, de – 2 m à – 5 m: alternance de couches concrétionnées avec des couches d'éboulis calcaires meubles et avec des couches plus noires, peut-être humifères. Couches archéologiques 10 à 18. — Niveau C, de – 5m à – 9 m: éboulis calcaires jaune-rougeâtre, avec, vers – 7.50 m, une couche de "sables soufflés", désertiques. Couches archéologiques 19 à 21. — Niveau D, de – 9 m à – 11.25 m: éboulis calcaires jaune-rougeâtre, avec, vers – 10 m, une couche d'éboulis mélés de galets et de silex roulés. Couches archéologiques 22 à 25.

Cette subdivision assez complexe, n'a pas emporté l'adhésion de tout le monde, et Waechter lui oppose la série bien plus simple du Mont Carmel, dans un article assez surprenant et qui appelle de multiples réserves, où il se livre à des acrobaties verbales pour faire rentrer Yabroud dans le cadre tracé au Mont Carmel*. Il conteste en particulier le Pré-Aurignacien de Rust (couche 15 de Yabroud I), que ce dernier rattache au Paléolithique supérieur, bien qu'il soit surmonté par plus de 10 couches moustériennes**.

Sans entrer dans le détail de notre analyse typologique des diverses couches de Yabroud, nous pouvons répéter ici que, dans l'ensemble, nos conclusions confirment formellement celles de Rust***: il existe à Yabroud, dans la couche 15, une industrie de type paléolithique supérieur, recouverte par une dizaine de couches moustériennes, seul cas connu jusqu'à présent d'une telle superposition****.

En effet: (1) ce Pré-Aurignacien *n'est pas* un Acheuléen dans lequel on n'aurait pas trouvé de bifaces et de racloirs à cause de la minceur des couches, comme le pense Waechter. La répartition des outils sur éclats ou lames est nettement différente de celle rencontrée dans l'Acheuléen sous-jacent (Figure 1), et l'indice laminaire***** est très nettement supérieur:

Couche	23	18	17	16
Indice laminaire	5.8	6.2	13.5	37

De plus, les caractéristiques typologiques diffèrent: pas de grattoirs carénés dans les couches acheuléennes, les caractéristiques générales ne coïncident pas, et il n'y

* En particulier, le Yabroudien serait... un Acheuléen sans bifaces!

** "Ce qui reste, c'est l'affirmation de Rust d'avoir trouvé ce complexe à lames sans les bifaces et racloirs associés. Etant donné la minceur des couches distinguées par Rust, cela ne nous semble pas démontré complètement" dit Waechter, (v. Références, 18).

*** Nous ne cachons pas qu'avant de voir l'industrie, nous étions nous-même sceptique.

**** Pour le détail de la typologie des autres couches, voir *L'Anthropologie*, **59**, 486 (1955).

***** Indice laminaire = pourcentage d'éclats dont la longueur dépasse le double de la largeur. Il comprend les vraies lames et les "éclats laminaires" des auteurs.

a pas de bifaces dans la couche Pré-Aurignacienne. Ceux qu'on y a trouvés sont fragmentaires, présentent une double patine; il s'agit de la réutilisation comme nucléus de bifaces plus anciens.

(2) Le Pré-Aurignacien est encore moins un Yabroudien, comme les couches 16 et 14 qui l'enserrent. Un simple coup d'oeil sur le graphique de répartition des outils

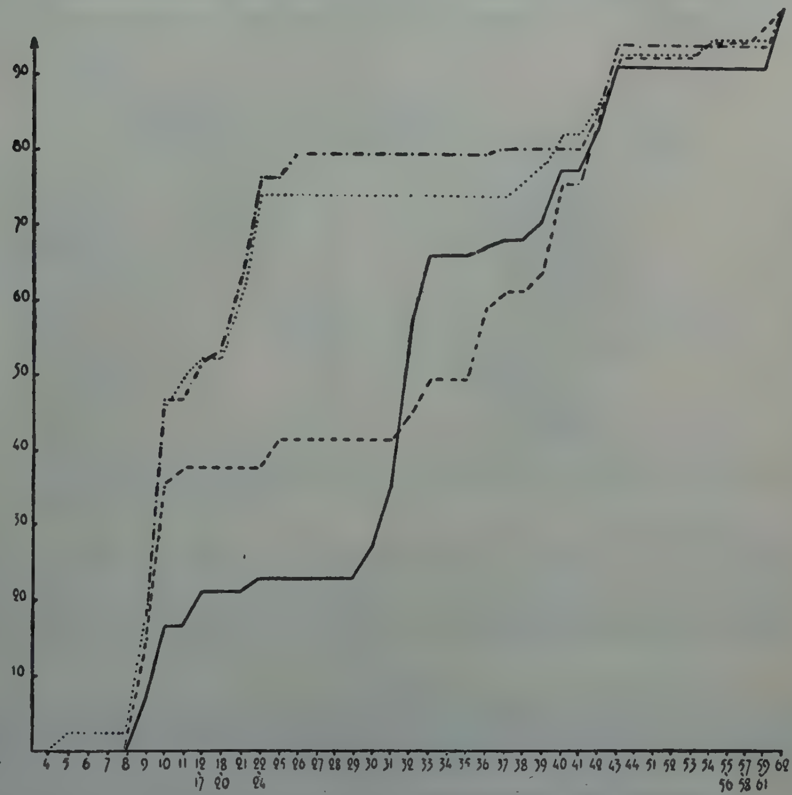

Figure 1

Diagrammes cumulatifs de la couche 15, Pré-Aurignacien (trait continu), de la couche 17, Acheuléen (trait interrompu), de la couche 16, Yabroudien (pointillé) et de la couche 14, Yabroudien (trait interrompu pointé) de l'abri I de Yabroud. Le diagramme cumulatif du Pré-Aurignacien est différent, aussi bien de ceux des couches yabroudiennes que de celui que donne l'industrie sur éclats de l'Acheuléen. Les diagrammes reproduits ici sont des diagrammes essentiels, où ne figurent ni les outils Levallois non retouchés, (nos. 1–3), ni les outils mal définis (nos. 45–50).

4, Pointes Levallois retouchées. 5, Pointes pseudo-Levallois. 6, Pointes moustériennes. 7, Pointes moustériennes allongées. 8, limaces. 9, racloirs simples droits. 10, racloirs simples convexes. 11, racloirs simples concaves. 12–17, racloirs doubles variés. 18–20, racloirs convergents variés. 21, racloirs déjetés. 22–24, racloirs transversaux variés. 25, racloirs sur face plane. 26, racloirs à retouche abrupte. 27, racloirs à dos aminci. 28, racloirs à retouche bifaciale. 29, racloirs alternes. 30–31, grattoirs typiques et atypiques. 32–33, burins typiques et atypiques. 34–35, percoirs typiques et atypiques. 36–37, couteaux à dos typiques et atypiques. 38, couteaux à dos naturel. 39, raclettes. 40, éclats et lames tronqués. 41, tranchets. 42, encoches. 43, denticulés. 44, Pointes burinantes alternes. 51, Pointes de Tayac. 52, Triangles à encoches. 53, Pseudo-microburins. 54, encoches en bout. 55, hachoirs. 56, rabots. 57–58, pièces atériennes. 59–61, choppers et chopping-tools. 62, divers.

sur éclats le montre tout de suite (Figure 1). Les racloirs déjetés (Winkelkratze de Rust), typiques du Yabroudien, manquent totalement dans le Pré-Aurignacien
(3) Le Pré-Aurignacien, au contraire, est assez proche de l'Aurignacien indiscut

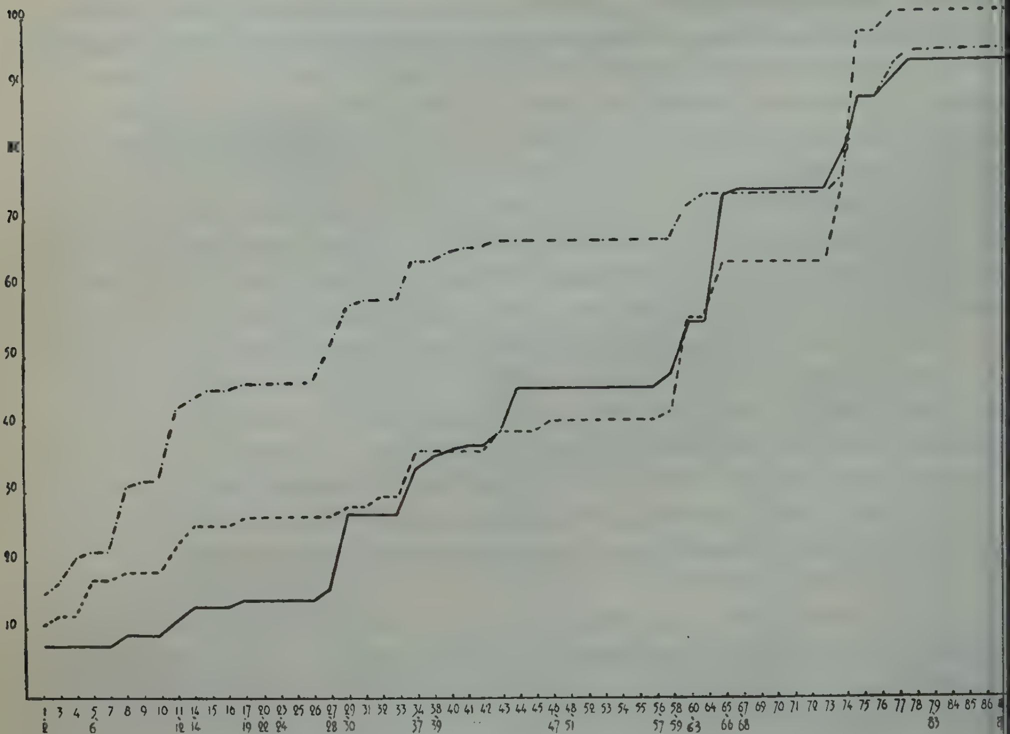

Figure 2
Diagrammes cumulatifs du Pré-Aurignacien de Yabroud I (trait plein) de l'Aurignacien de la couch 7 de Yabroud II (trait interrompu) et de la couche 6 (trait interrompu pointé). La couche 7 e statistiquement plus proche du Pré-Aurignacien que de la couche 6.

1–2, grattoirs sur bout de lame, typiques et atypiques. 3, grattoirs doubles. 4, grattoirs ogivau 5–6, grattoirs sur lames retouchées et sur lames aurignaciennes. 7, grattoir éventail. 8, grattoirs su éclats. 9, grattoirs circulaires. 10, grattoirs unguiformes. 11–12, grattoirs carénés typiques et atypique 13–14, grattoirs à museaux, typiques et atypiques. 15, grattoirs nucléiformes. 16, rabots. 17–1 outils composites (grattoirs-burins, etc.). 20–22, outils composites comprenant un perçoir. 23–2 perçoirs et perçoirs atypiques. 25, perçoirs multiples. 26, microperçoirs. 27–28, burins dièdr droits et déjetés. 29–30, burins dièdres d'angle et burins dièdres sur lame cassée. 31, burins dièdr multiple. 32, burins busqués. 33, burins bec-de-perroquet. 34–37, burins sur troncatures retouché variées. 38–39, burins transversaux. 40, burins multiples sur troncatures retouchées. 41, buri multiples de type mixte. 42, burins de Noailles. 43, burins nucléiformes. 44, burins plans. 45, coutea type Audi. 46–47, couteaux de Chatelperron, typiques et atypiques. 48–51, Pointes de la Gravett 52, Pointes de Font-Yves. 53, pièces à dos gibbeux. 54, bléchettes. 55, Pointes à soie (Font-Robert 56–57, Pointes à cran atypiques (périgordiennes) et pièces à cran. 58–59, lames à dos typiques atypiques. 60–63, lames tronquées. 64, lames bitronquées. 65–66, lames à retouches continue 67–68, lames aurignaciennes et lames étranglées. 69, Pointes à face plane. 70, feuille de lauri 71, feuilles de saule. 72, Pointes à cran typiques (solutréennes). 73, pics. 74, encoches. 75, denticul 76, pièces esquillées. 77, racloirs. 78, raclettes. 79–83, pièces géométriques. 84, lamelles tronqué 85, lamelles à dos. 86, lamelles à dos tronquées. 87–89, lamelles denticulées. 90, lamelles Dufou 91, Pointes aziliennes. 92, divers.

de la couche 7 de l'abri II (Figure 2). Il semble même que cette couche 7 soit typologiquement plus proche du Pré-Aurignacien que de la couche 6 qui la surmonte !

Enfin, après le passage des Pré-Aurignaciens, on observe à Yabroud, sauf pour les couches 12 (acheuléenne), 14 et 11 (Yabroudiennes), une nette augmentation de l'indice laminaire dans le "Levalloiso-Moustérien", augmentation qui culmine dans la couche 9, dans laquelle on peut voir soit une industrie mixte, moustéro-préaurignacienne, soit le passage, sur un même sol d'habitat, de moustériens et de pré-aurignaciens (Tableau I).

TABLEAU I

Indices laminaires des diverses couches de Yabroud (Abri I)

c. 25:	Yabroudien	7.3	c. 11:	Moustérien	16.7
c. 24:	Yabroudien	5.7	c. 10:	Moustérien	23.1
c. 23:	Acheuléen	5.8	c. 9:	Moustérien	49.8
c. 22:	Yabroudien	7.1	c. 8:	Moustérien	37.1
c. 18:	Micoquien	6.2	c. 7:	Moustérien	36.6
c. 17:	Acheuléen	13.6	c. 6:	Moustérien	21.6
c. 16:	Yabroudien	3.6	c. 5:	Micromoustérien	16.3
c. 15:	*Pre-Aurignacien*	37.3	c. 4:	Moustérien	20.3
c. 14:	Yabroudien	9.0	c. 3:	Moustérien	22.0
c. 12:	Acheuléen	14.0	c. 2:	Moustérien	24.4

Les couches 21,20,19 et 13 ne comportaient pas assez d'objets. La couche 1, partiellement remaniée, n'a pas été étudiée statistiquement.

Ayant ainsi établi la réalité du Pré-Aurignacien de Rust, il reste à déterminer son âge et ses rapports chronologiques avec les autres industries. D'abord, est-il possible de synchroniser, sur une base typologique, Yabroud avec d'autres gisements, et en particulier le Mont Carmel et Ksar Akil?

Au Mont Carmel, Miss Garrod note, dans la couche E d'Et-Tabun, micoquienne, une augmentation brutale du nombre des lames et des burins, et l'existence de grattoirs carénés* (1937), principalement à partir du niveau Eb. Une couche pré-aurignacienne existait-elle là aussi, comme Rust est porté à le croire, ou bien s'agissait-il seulement d'une influence, seules de nouvelles fouilles avec les méthodes modernes de repérage des objets permettrait de le trancher. Quoi qu'il en soit, on peut supposer, comme point de départ, que les couches pré-Aurignaciennes de Yabroud (couches 15 et 13) sont contemporaines de la couche E d'Et-Tabun. La couche 12 de Yabroud correspondrait assez bien, pour la typologie des bifaces, avec la couche Ea de Tabun, et, immédiatement au-dessus de ces deux couches commence le "Levalloiso-Moustérien", avec, à Yabroud, quelques détails qui ne semblent pas se retrouver au Mont Carmel (couches 9 et 5 de Yabroud). En cherchant dans le détail, on pourrait même paralléliser la base de la couche C, à Et-Tabun, à éclats Levallois ovales, avec la couche 7 de Yabroud, et le haut de cette même couche C, à éclats Levallois allongés,

* "... further back still, all these types of blade-tools together with steep scrapers, suddenly appear, then disappear again, in the heart of the final Acheulean, both in Tabun cave and at Jabrud".

avec la couche 4 de Yabroud. Mais peut-être est-ce pure coïncidence. De même les couches levalloiso-moustériennes de Yabroud (couches 10 à 1) pourraient se paralléliser avec la base de Ksar Akil, mais ceci est purement hypothétique.

Après le Levalloiso-Moustérien du Mont Carmel se place le niveau à pointes d'Emireh (El Wad G et F) puis l'Aurignacien du Mont Carmel (Paléolithique supérieur III–IV de Neuville) puis l'Atlitien (Paléolithique supérieur V). Cet Emirien est raviné, et doit être suivi d'une lacune stratigraphique correspondant au Paléolithique supérieur II de Neuville, absent au Mont Carmel, mais existant à Ksar Akil après l'Emirien. A Yabroud, il n'y a pas d'Emirien, mais, prenant la suite de l'abri I se place l'abri II, avec à sa base trois couches moustériennes, que l'on pourrait peut-être paralléliser avec les couches supérieures de l'abri I, comme montre le tableau II. Puis viennent les couches 7 à 2, aurignaciennes. Les couches 5 à 2 entrent assez facilement dans le Paléolithique supérieur III de Neuville (l'Atlitien? de Rust étant du Paléolithique supérieur III pour Miss Garrod). Il semble difficile de placer les couches 7 et 6 dans ce niveau, cependant, car elles ne comportent pas de pointes de Font-Yves, mais elles ne semblent pas non plus correspondre très bien au Paléolithique supérieur II de Neuville. Peut être est-ce du III*a*?

Cette équivalence typologique établie, et il ne semble pas qu'elle puisse être très modifiée, il reste à déterminer la chronologie de ces différentes industries. Rust, se fondant sur la chronologie proposée autrefois par Miss Garrod et Miss Bate (1937) au Mont Carmel, place la série acheuléenne et la série yabroudienne dans le dernier interglaciaire, ce qui revient à vieillir au maximum le Pré-Aurignacien, qui serait antérieur au Wurm. C'est là un point de vue extrême .La datation du Mont Carmel a d'ailleurs été critiquée par R. Vaufrey (1939) aussi bien que par R. Neuville (1951).

Miss Garrod, admettant l'équivalent glacial-pluvial, place l'Emirien dans un interstade, car les couches émiriennes ont été partiellement détruites par le pluvial qui a suivi. Dans ce cas, il s'agirait au plus tôt de l'interstade II/III*, et l'Aurignacien de Palestine (en y comprenant le Paléolithique supérieur II) serait exactement contemporain de l'Aurignaco-Périgordien (le Perigordien I, interstadial, exclu), du Solutréen et du Magdalénien français, le Kébarien (Paléolithique supérieur VI) correspondant au Magdalénien final. Mais dans ce cas, il faut d'une part, ou rejeter le Pré-Aurignacien de Yabroud très bas, ce qui est peu vraisemblable, ou comprimer dans un laps de temps relativement très court toutes les couches comprises entre le Pré-Aurignacien et le niveau d'Emireh, c'est à dire les couches 14 à 1 de Yabroud; d'autre part, il faut étendre sur un très long temps le Paléolithique supérieur II: en effet, si l'on suppose avec Miss Garrod — et nous agréons sur ce point — que le Paléolithique supérieur III est sensiblement contemporain du Solutréen occidental,

* Miss Garrod, se fondant sur la chronologie allemande, le place dans l'inter-stade I/II. A la suite de Commont, nous estimons que les Wurm I et II, tels que les montrent les loess du Nord de la France, ont été occupés par le Moustérien. Le Wurm IV, magdalénien, ne se marque pas dans le loess en France, tandis que le loess I semble manquer en Allemagne.

TABLEAU II

1	2	3	4	5	6
POST-WURM	Azilien		Natoufien		
WÜRM IV	Magd. VI V IV		lacune		1 ?
III - IV	Magd. I-III Solutréen		C D E		2 3 4 5
III b	Protosolutréen Auri V Périg. IV-V		Ravinement		Changement de sédimentation
IIIa-IIIb	Périg. moyen		F (Emirien)		8
IIIa	Auri. II Auri. I Périg. I évolué	B Rupture faunique	G	1 2 3	9 10
II - III	Auri. "0" Périg. I Moust. final	C D		4 5 6 7 8 9 10 11	
WURM II	Moust. sup.	Ea Eb Ec Ed		Acheul. final 12 Pré-Auri. 13 Yabroudien 14 Pré-Auri. 15 Yabroudien 16 Acheul. 17 Micoquien 18 Acheul. ? 19 Yabroudien 20	
I - II	Moust. moy.			Yabroudien 21 Sables soufflés	
WÜRM I	Moust. inf. Micoquien	F ?		Yabroudien 22 Acheul. 23 ? 24 Yabroudien 25	
	FRANCE	ET-TABUN	EL WAD	YABRUD I	YABRUD II

cela place son début environ 20,000 ans avant notre ère*. Le Périgordien I, interstadiaire, dont l'Emirien serait contemporain, peut être placé aux environs de 30,000 ans avant notre ère. Cela ferait donc, pour le Paléolithique supérieur II, une durée de dix mille ans.

D'un autre côté, il serait difficile de placer l'Emirien dans l'interstade III/IV, ce qui le ferait contemporain du Solutréen français, rejetant le Paléolithique supérieur III–IV trop haut.

Si au contraire on considère que le Pré-Aurignacien ne peut être beaucoup plus ancien que l'Aurignacien occidental**, on ne peut le placer plus bas que la fin du Wurm II, ce qui le ferait déjà nettement antérieur à celui d'Europe occidentale, où il date de la fin de l'interstade II/III — couche E′ de la Ferrassie, ancien Périgordien II*** (de Sonneville – Bordes 1955) — et du début du Wurm III****. Comme, nous l'avons dit, on ne peut guère télescoper dans cet interstade II/III l'Emirien et tout le Levalloiso-Moustérien de Palestine sans supposer un formidable taux d'accumulation dans les abris; on est obligé de rajeunir l'Emirien. On pourrait alors le paralléliser avec le petit stade d'arrêt dans le dépôt du loess qui sépare, en France, le loess III*a* du loess III*b*, stade pendant lequel se développe le Périgordien moyen. Le Paléolithique supérieur II de Palestine correspondrait alors, en durée, au loess III*b* et au Périgordien supérieur et Protosolutréen occidental. Le ravinement de l'Emirien en Palestine correspondrait au retour d'humidité au début du Wurm III*b*.

Mais, tout compte fait, le ravinement de l'Emirien, postérieur à son dépôt, signifie-t-il que celui-ci se soit fait pendant un interstade? En Europe, les ravinements datent souvent des interstades. Et si l'on accepte l'interprétation de Garrod***** pour Ksar Akil, ce dernier gisement a vu une accumulation plus forte pendant les interstades que pendant les stades, ce qui est contraire à ce qui se passe en Europe occidentale. On ne voit pas très bien, d'ailleurs, comment un interstade tempéré et sec aboutirait

* Le début du Périgordien IV étant daté, à l'abri Pataud, aux Eyzies, d'environ 22,000 ans avant notre ère par le radiocarbone (fouilles H. Movius), le Solutréen ne peut guère remonter au-delà de 18 à 20,000 ans. Quant au Périgordien I, il n'y a aucune raison de penser qu'il soit beaucoup plus récent — si même il l'est — que le Paléolithique supérieur (Baradostien) trouvé à Chanidar (Irak) par R. Solecki, et que le radiocarbone date de 32,000 ans au moins avant notre ère. Dix mille ans seraient donc, dans l'hypothèse de Miss Garrod, la durée *minimum* du Paléolithique supérieur II. Cela semble beaucoup pour cette industrie.

** Il semble difficile de croire que l'Aurignacien ait pu être contemporain pendant longtemps en Europe orientale des industries moustériennes sans donner lieu à des interstratifications du type Yabroud, qui, jusqu'à présent, n'ont pas été rapportées. Et s'il est vrai qu'en Occident certains niveaux d'Acheuléen supérieur, vers la fin de l'interglaciaire (Levalloisien IV de Breuil) comportent un bon nombre de lames, celles-ci ne sont pas accompagnées par de nombreux burins ou grattoirs, ni par des grattoirs carénés.

*** Qui est en réalité de l'Aurignacien typique.

**** Il n'est certainement pas interstadiaire, comme le pense Miss Garrod, car l'Aurignacien I livre une faune très froide, comprenant le renard bleu, le boeuf musqué et le lemming à collier.

***** The relations between South-West Asia... tableau final. Il nous semble d'ailleurs que Miss Garrod a mal interprété la pensée d'Ewing: ce dernier considère que les complexes caillouteux de ce gisement pourraient correspondre aux périodes humides *d'avancée* des Wurms I, II et III. Nous pensons qu'il s'agit plutôt des périodes humides d'avancée des Wurms III*a*, III*b* et IV.

à une accumulation, sinon de sables soufflés. Les stades du Wurm, au moins les supérieurs, se marquent à leur apogée en France, tout près de l'Atlantique, par une grande sécheresse. Il semble difficile qu'ils soient humides au bout oriental de la Méditerranée. Par contre, les interstades, et le *début* des stades sont nettement humides. Peut-être faudrait-il distinguer entre les conditions interglaciaires, qui peuvent être sèches au Moyen-Orient, et les interstades, qui peuvent y être humides. Après tout, dans le premier cas, la calotte glaciaire est presque totalement fondue, alors que dans le second cas, elle est seulement légèrement réduite. Il semble difficile que les conditions météorologiques soient les mêmes dans les deux cas.

Dans l'absence de bons documents sédimentologiques, il nous semble donc que des considérations purement typologiques ne sont pas dépourvues d'intérêt, ne serait-ce que comme hypothèses de travail.

Le graphique de fréquence Daim-Gazelle, publié par Miss Garrod et Miss Bate dans leur ouvrage sur le Mont Carmel, soulève quelques difficultés*. Il place les couches Ed, Ec et Eb d'Et-Tabun dans une phase humide, Ea et surtout D et C dans une phase sèche. La couche B d'Et-Tabun, ainsi que la couche G d'El Wad sont à nouveau dans une phase humide, les couches F (Emirien) et E (Paléolithique supérieur III) à nouveau dans une phase sèche, la couche D (Paléolithique supérieur IV) marquant une nouvelle petite pointe d'humidité. Mais si l'on accepte l'interprétation d'Ewing pour Ksar Akil, il doit s'intercaler une nouvelle phase humide, correspondant au Paléolithique supérieur II de Ksar Akil et à la lacune d'El Wad**.

En supposant donc que le lien typologique net entre le Pré-Aurignacien de Yabroud I et l'Aurignacien de la couche 7 de Yabroud II signifie bien qu'un temps relativement court s'est écoulé entre eux, on arriverait au tableau de corrélations proposé ici (Tableau II), assez satisfaisant d'*un point de vue théorique*.

Dans cette hypothèse, l'Emirien ne peut être une industrie de passage entre le Levalloiso-Moustérien et l'Aurignacien palestinien, car il est très nettement postérieur, de toute manière, au Pré-Aurignacien de Yabroud. Peut-être, s'il y a de vrais couteaux de Chatelperron dans les couches de type émirien*** pourrait-il s'agir d'une évolution avortée vers un "Périgordien", indépendant de la série aurignacienne. Miss Garrod avait déjà eu une impression analogue****. Cette évolution présenterait alors une convergence avec le Périgordien français, mais serait indépendante. Peut-être aussi s'agit-il d'une évolution vers un *troisième type* de Paléolithique supérieur?

Le Levalloiso-Moustérien de Palestine daterait, dans notre hypothèse, du Wurm

* Contrairement à R. Vaufrey et à R. Neuville (*loc. cit.*), nous pensons que l'alternance Daim-Gazelle a plus de chances de représenter des variations dans la composition du gibier accessible que des variations de goût chez les chasseurs paléolithiques.

** Le maximim d'humidité de la couche D ne serait d'ailleurs pas confirmé par d'autres gisements d'après Miss Garrod. *Loc. cit.* p. 30.

*** Ceux publiés par Garrod dans son ouvrage sur le Mont Carmel ne sont pas très convainquants.

**** "In general, however, the Emiran has the appearance of an emerging blade culture which could more readily develop a Gravettian than an Aurignacian character." *Loc. cit.*, p. 33.

III*a* et de l'interstade II/III, et serait donc tardif. En Occident, le Moustérien final occupe le début de l'interstade II/III* (Bordes 1953). Nous connaissons par ailleurs une industrie moustéroïde qui est contemporaine du Paléolithique supérieur français, et date donc du Wurm IIIa, c'est l'Atérien d'Afrique du Nord, dont certains gisements anciens (El Guettar, Tunisie) ne sont pas sans ressembler au Moustérien du Moyen-Orient, comme le remarque le Dr. Gruet.

Il pourra sembler abusif, cependant, de placer l'Acheuléen supérieur ou le Micoquien de Palestine dans le Wurm II. A vrai dire, plus que d'un vrai Acheuléen supérieur, au sens occidental du mot, il pourrait s'agir d'un faciès oriental du Moustérien de tradition acheuléenne. On oublie souvent que le Moustérien de tradition acheuléenne a été parfois artificiellement vieilli pour des considérations de typologie théorique (présence de bifaces), alors que parfois il est tardif, datant du Wurm II (Bordes 1954–1955), et que le vrai Micoquien de la Micoque date du début du Wurm, et non point du dernier interglaciaire, encore moins du Riss. Les formes acheuléennes tardives ne sont pas si rares qu'on le croit**. Par ailleurs, en Europe occidentale, les dépôts du début du Wurm sont plus rares qu'on ne le pense dans les grottes et abris. Les abris wurmiens semblent s'être creusés au début de cette période froide, comme l'indique Guillien (1946) et ne pouvaient donc être habités avant d'exister. Des abris plus anciens, nous ne connaissons que la Micoque. Quant aux grottes, elles semblent avoir subi souvent, au début du Wurm II, une vidange plus ou moins complète, ce qui fait que les dépôts anciens ne s'y rencontrent pas si souvent que l'on pourrait le penser (Bordes 1954–1955).

Si l'on accepte notre point de vue, un certain nombre de faits difficiles à expliquer deviennent clairs: on peut penser que les Pré-Aurignaciens de Yabroud représentent une première descente vers le Sud, vers la fin du Wurm II ou le début de l'interstade II/III, d'Aurignaciens primitifs venant de Russie ou d'Anatolie (?) ***, cette descente se marquant par l'intercalation de niveaux de type paléolithique supérieur (couches 15 et 13 de Yabroud) dans la masse acheuléo-yabroudo-moustérienne. Mais cette première invasion, trop faible en nombre, se retire ou est "digérée", laissant comme trace de son passage, outre les niveaux de Yabroud et l'influence(?) dans l'Acheuléen tardif du Mont Carmel****, un débitage plus laminaire dans le Moustérien, plus sensible à Yabroud qu'au Mont Carmel, et une race mixte, dite "de Palestine".

* Nous le connaissons à ce niveau à Goderville (Seine Maritime) *de Paleontologie Humaine*, Mém. **26**, 292 *et seq*.

** Comment en signale à la base du loess II (Les Hommes contemporains du Renne, fig. 42) plus souvent à la base du loess I. A la Chaise (Charente), dans le Moustérien de tradition acheuléenne, les bifaces, rares, sont de type acheuléen.

*** Il serait intéressant de faire l'étude statistique du Baradostien de Chanidar.

**** Les esprits romanesques, pour expliquer la contradiction apparente entre les faits observés à Yabroud, où le Pré-Aurignacien est bien distinct, et au Mont Carmel, où ses outils seraient mêlés à ceux de l'Acheuléen, peuvent supposer que les Acheuléens, ayant détruit les mâles d'une tribu pré-aurignacienne et enlevé les femmes, ces dernières auraient continué à fabriquer l'outillage qui leur était familier, et l'aurait laissé pêle-mêle avec les racloirs et les bifaces de leurs néandertaliens compagnons!

Pendant quelques millénaires, les Moustériens de Palestine, adossés à l'énorme masse moustéroïde attardée d'Afrique, reconquièrent le terrain perdu et évoluent peut-être à leur tour, typologiquement au moins, vers une industrie à tendance paléolithique supérieur, l'Emirien. Mais la seconde vague plus massive, d'Aurignaciens, qui déferle vers le Sud au Wurm III*b*, interrompt ce processus, poussant même, si Vignard ne s'est pas trompé, une influence faible et tardive jusqu'en Egypte. Ils continuent leur évolution sur place au Wurm III*b* et au Wurm IV, et sont à leur tour recouverts par un Mésolithique qui semble conserver encore une faible tradition aurignacienne (carénés du Natoufien).

On peut supposer qu'à cette même époque où les Pré-Aurignaciens tentaient leur premier essai de descente vers le Sud, une autre partie s'est dirigée vers l'Ouest, au cours de l'interstade II/III, et arriva jusqu'en France, où l'Aurignacien, qui ne semble pas avoir de racines locales* se place immédiatement au-dessus du Périgordien I**, lui-même datant de cet interstade II/III. Cette théorie pourrait être soutenue par le fait suivant: dans le Pré-Aurignacien aussi bien que dans les niveaux inférieurs de l'Aurignacien de Palestine, les grattoirs carénés se rencontrent en proportions assez faibles, se développant plus tard. Or, si ces carénés semblent jouer un grand rôle en France du Sud-Ouest dès le début, il n'en est pas de même au Vogelherd (Allemagne du Sud) ou à Arcy-sur-Cure ("Périgordien II") (Bailloud 1953), alors que le Vogelherd est par ailleurs typiquement Aurignacien I. Il pourrait s'agir d'étapes?

Pour terminer, nous ne nous dissimulons nullement les difficultés soulevées par notre interprétation, *la forte part d'hypothese qu'elle comporte*, ni surtout les critiques qu'elle va subir. On pourrait en particulier demander ce qui, en Palestine, occupe le Wurm I. Ce pourrait être l'Acheuléen d'Oum Qatafa, en partie tout au moins, car il semble être plus un Acheuléen supérieur qu'un Acheuléen moyen. Il se pourrait aussi que l'interstade I/II soit faiblement marqué en Palestine, ou pas du tout. (Il pourrait correspondre aux sables soufflés de Yabroud.) Ce qui correspond au Riss pourrait être le "Tayacien" d'Oum Qatafa ou les couches inférieures de Yabroud. Mais les dépôts rissiens sont-ils plus nombreux dans les grottes du Moyen-Orient qu'en Europe occidentale? Et le fait que dans des plages soulevées "anciennes" on trouve des industries comparables à celles des grottes ne doit pas faire illusion: l'évolution typologique de l'Acheuléen et des industries qui lui sont contemporaines a été très lente, et n'est souvent sensible que statistiquement***, même en Europe occidentale.

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* Les ressemblances qu'il présente avec le Moustérien type Quina sont trop faibles pour pouvoir être autre chose qu'une convergence, en France tout au moins.

** Ce dernier semble s'enraciner, en France, dans le Moustérien de tradition acheuleénne.

*** Il y a en particulier de fortes ressemblances typologiques entre la couche 3 de la Micoque (rissienne) ou le Clactonien d'High Lodge (Riss–Wurm au moins), ou l'industrie des tufs d'Ehringsdorf (Riss–Wurm) et le Moustérien du type La Quina, souvent tardif. L'industrie sur éclats de l'Acheuléen supérieur du Tillet (Seine et Marne), de la base du loess ancien III (rissien) est pratiquement impossible à distinguer, typologiquement, de celle du Micoquien, et même du Moustérien de tradition acheuléenne (wurmien) du même gisement.

Dans notre hypothèse, la rupture faunique se placerait très tard (Tabun B) c'est à dire, au début du Wurm III. Mais n'a-t-on pas trouvé du Rhinocéros de Merck en abondance dans le Moustérien du Castillo, certainement wurmien, et peut être aussi jusque dans l'Aurignacien? Le Rhinocéros de Merck et l'hippopotame ont même duré en Italie (Vaufrey 1939) jusqu'au Moustérien supérieur, et, à Romanelli, jusqu'au début du Paléolithique supérieur, c'est à dire au moins jusqu'à la fin du Wurm II. Il semblerait donc bien que la "rupture faunique", tout autour de la Méditerranée, se place au même moment, au début du Wurm III.

A tout point de vue, la Syrie-Palestine aurait joué le rôle de pont entre le continent africain, dont nous avons de multiples raisons, comme l'indique R. Vaufrey (1955) de penser *qu'a cette époque* il était attardé, et l'Europe, continent "progressiste". En tous cas, ce n'est certainement pas par hasard que dans cette région se rencontrent les faits, uniques en leur genre jusqu'à présent, de niveaux paléolithiques supérieurs recouverts par des couches moustériennes et de formes humaines morphologiquement intermédaires entre le Néandertal et *l'Homo sapiens*. Qu'il s'agisse d'hybrides plutôt que de formes de passage semble indiqué par l'existence antérieure du Pré-Aurignacien de Yabroud. Et quelle que soit la chronologie que des travaux ultérieurs tireront d'une étude, à peine ébauchée, des sédiments des grottes, on devra tenir compte de ce fait.

ADDENDUM

Récemment (Garrod 1956), Miss Garrod a essayé de répondre à mon article paru dans *L'Anthropologie* (Bordes 1955). Je donnerai une réponse à cette réponse. Il me suffit de dire ici qu'après avoir reconnu l'existence probable de plusieurs niveaux Pré-Aurignaciens à Et Tabun, Miss Garrod essaye de dater le Moustérien de ce gisement et celui d'El Wad par comparaison avec des industries trouvées en rapports plus ou moins étroits avec des plages soulevées. Or: (1) les rapports de ces industries avec les plages ne sont pas nets; (2) certaines de ces "industries" sont représentées en réalité par quelques éclats (Fleisch 1946), sur lesquels il est pour le moins téméraire de déterminer un "Levalloisien évolué"; (3) Miss Garrod ne semble pas se rendre compte du caractère statique des industries moustériennes, qui évoluent avec une extrême lenteur, ce qui fait que certains Moustériens du début du Wurm I sont identiques à certains de la fin du Wurm II, à quelques différences statistiques près, très délicates d'ailleurs à apprécier. Les dates obtenues par le radiocarbone, données dans cet article, n'ont donc pas de valeur probante. Cependant des dates auraient été obtenues récemment pour Et Tabun B, qui décaleraient légèrement vers le bas la colonne 3 du tableau II, la couche B devenant plus ou moins contemporaine du Périgordien I, sans que pour cela on soit obligé de mettre le Pré-Aurignacien plus bas que la deuxième partie du Wurm II. Ajoutons que, partant d'un point de vue différent, F. Clark Howell arrive aux mêmes conclusions, si l'on se souvient qu'il utilise la chronologie classique, et que son Wurm I correspond à nos Wurm I et II (Howell 1958).

RÉFÉRENCES

1. Bailloud, G., 1953, Note préliminaire sur l'industrie des niveaux supérieurs de la Grotte du Renne, à Arcy sur Cure, *Soc. préhist. France, Bull.* 338.
2. Bordes, F., 1950, Principes d'une méthode d'étude des techniques de débitage et de la typologie du Paléolithique ancien et moyen, *L'Anthropologie*, **54**, 19.
3. Bordes, F., 1953, Les limons quaternaires du bassin de la Seine, *Inst. Paléontologie Humaine Archives*, **26**, 475.
4. Bordes, F., 1954–1955, Les gisements du Pech de l'Azé (Dordogne), I, le Moustérien de tradition acheuléenne, *L'Anthronologie*, **58**, 401 et **59**, 1.
5. Bordes, F., 1955, Le Paléolithique inférieur et moyen à Jabrud (Syrie) et la question du Pré-Aurignacien, *L'Anthropologie*, **59**, 486.
6. Bordes, F., et Bourgon, M., 1951, Le complexe moustérien, *L'Anthropologie*, **55**, 1.
7. Fleisch, H., 1946, Le Levalloisien du niveau +15 à Ras Beyrouth, *Soc. préhist. France, Bull.* 299.
8. Garrod, D., 1953, The relations between South-West Asia and Europe in the later Paleolithic Age, *Cahiers d'Histoire mondiale*, I, **1**, 33.
9. Garrod, D., 1956, Acheuléo-Jabroudien et "Pré-Aurignacien" de la Grotte du Taboun (Mont Carmel), étude stratigraphique et chronologique, *Quaternaria*, **3**, 39.
10. Garrod, D., Bate, D., 1937, *The Stone Age of Mount Carmel*, **1**, Oxford.
11. Guillien, Y., 1946, Pour la chronologie de la période froide; les données charentaises, *Soc. belge Géologie, Sess. extraordinaire*, 347, *Gand*-Bruxelles.
12. Howell, C., 1958, Upper Pleistocene men of the Southwest Asian Mousterian, *Neanderthal centenary*, Kemink en Zoon, Utrecht.
13. Neuville, R., 1951, Le Paléolithique et le Mésolithique du Désert de Judée, *Inst. Paléontologie Humaine Archives*, **24**, 270.
14. Rust, A., 1950, *Die Höhlenfunde von Jabrud (Syrien)*, éd. Karl Wacholtz, Neümuster.
15. Sonneville-Bordes, D. de, 1955, La question du Périgordien II, *Soc. préhist. Fr.ance, Bull.* 187.
16. Vaufrey, R., 1939, Paléolithique et Mésolithique palestiniens, *Rev. sci.*, 390.
17. Vaufrey, R., 1955, Préhistoire de l'Afrique, I, Maghreb, *Inst. Hautes Etudes Tunis Pubs.*, éd. Masson, Paris.
18. Waechter, The excavations of Jabrud and their relation to the prehistory of Palestine and Syria, *Tirage-à-part, sans lieu ni date*, 10.

A *STEGODON* FROM ISRAEL

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ABSTRACT

Description of a fragment of a molar of *Stegodon* from the Middle Pleistocene of Jisr Banāt Yaqūb, the first evidence of the presence of a stegodont in Israel, forming a link between the south-eastern Asiatic and the African stegodonts.

The discovery of fossil remains of mammals at the old bridge Jisr Banāt Yaqūb, about 4 km south of Lake Huleh, at present at the Israel–Syrian frontier, dates from 1933. Collections made in the years 1935–1937 and 1950–1952 have been studied by this author (Hooijer 1960), and the following is the faunal list resulting from these studies:

Elephas trogontherii Pohlig	*Hippopotamus amphibius* L.
Equus cf. *caballus* L.	*Dama* cf. *mesopotamica* (Brooke)
Dicerorhinus merckii (Jaeger)	*Cervus* cf. *elaphus* L.
Sus cf. *scrofa* L.	cf. *Bison priscus* (Bojanus)

As already related in the Addendum of the above reference, a fragment of a proboscidean molar sent to me for identification by Professor G. Haas of The Hebrew University, Jerusalem, in November 1959 represents *Stegodon*, a hitherto undescribed element to the Jisr Banāt Yaqūb fauna; this find will be described and discussed in the present paper.

According to information from Professor Haas, the specimen in question was collected at Jisr Banāt Yaqūb in 1951, and originates from the base of Bed V, at a depth of 3.40 m. It was identified by Dr. A. T. Hopwood on photographs as "a form more primitive than *Elephas meridionalis*", and it is on the base of this fragment that *Elephas meridionalis* has been listed as occurring in Bed V of Jisr Banāt Yaqūb by Stekelis (1956). The reason why this specimen had not been sent to me along with the other proboscidean material from the site in the summer of 1959 is that it was for the time being kept in Professor Haas's laboratory at The Hebrew University, Professor Haas being on leave abroad. The fauna associated with the *Stegodon* at the base of Bed V consists of *Elephas trogontherii*, *Dicerorhinus merckii*, *Hippopotamus amphibius*, and cf. *Bison priscus*. The faunal remains of Jisr Banāt Yaqūb have been found at depths ranging from 0.42 m (top of layer B) down to 3.40 m (base of Bed V), but the elephant remains the same all through this sequence of beds — there is no evidence

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of a progressive change as we pass upward along the series of layers. The fauna can be dated as approximately Second or Great Interglacial (Interpluvial), Mindel-Riss (Hooijer 1960). Hence the *Stegodon* may be given the same age, Middle Pleistocene, and it may for convenience be distinguished as:

Stegodon mediterraneus nov. spec.

Holotype: Fragment of M^3 sin. described and figured in the present paper; collection of the Zoology Department, The Hebrew University, Jerusalem.
Locality: Jisr Banāt Yaqūb, 4 km south of Lake Huleh, Israel.
Age: Middle Pleistocene.

Diagnosis: An advanced species of *Stegodon* with unworn full molar ridges two-thirds as high as wide at base; about 9–10 conelets per ridge. Four ridges in 10 cm of anteroposterior length in M^3; number of ridges in last molars probably 10–12.

Description: The fragment (Plate I), as indicated by the rootward concavity of the crown base, the mode of wear, and its posterior taper, represents part of an upper left last molar. It comprises two ridges, one of which just touched by wear, and the other showing the apices of the dentine cores of some conelets, the enamel rings not having united into a single figure yet. The enamel, shown at broken edges, has a thickness of 4–6 mm, and is finely wrinkled on the surface. Each of the ridges is clearly divided into four main parts each consisting of two or three conelets, making 9–10 conelets per ridge. The posterior ridge is roof-shaped, and decidedly lower than wide; the basal width is 77 mm by a height of 48 mm; in the unworn state this ridge would not have exceeded 50 mm in height. The anterior, more worn ridge is wider: at least 81 mm transversely at the base (the ridge is incomplete buccally). The grinding surface falls off rootward toward the buccal side; the height of the least worn lingual conelet of the anterior ridge is 45 mm. The valley between the two ridges is filled with cement, which also covers the lingual and buccal edges, and leaves only the apical 8–12 mm of the ridges exposed. The level of the cement is decidedly higher in the lingual than in the buccal half of the valley. The ridges are not straight transversely but slightly sinuous, concave to the front in the centre, and convex to the front lingually as well as buccally. The fragment is broken off at the bases of the valleys in front and behind the two ridges; the valley bottoms are sharply raised in the middle, forming a point at either side of which the bottoms are concave transversely crownward. One ridge and one cement interval occupy 25–27 mm of anteroposterior length. Roots have broken off.

Discussion: The characters presented by the fragment, in particular the low ridges, only about two-thirds as high as wide in the unworn state, the thickness and wrinkling of the enamel, the great number of conelets, and the absence of median expansions of the ridges, indicate that the specimen belongs to *Stegodon*. Ridges of the same width and height as those in the Jisr Banāt Yaqūb specimen may be found in the posterior upper molars of advanced stegodonts like *Stegodon insignis* (Falconer

et Cautley) from Lower and Middle Pleistocene deposits of the Siwaliks of India or *Stegodon trigonocephalus* Martin found in the Early, Middle, and Late Pleistocene o Java (Table I).

TABLE I
Measurements of unworn ridges of M^3 of *Stegodon* (in mm)

	Stegodon	*insignis*	*Stegodon*	*trigonocephalu*
No. of ridge from behind	3	2	3	2
Basal width	87	76	84	78
Height	51	47	52	49
Height-width index	59	62	62	63

The pairs of ridges of the specimens recorded in Table I, which are in the Duboi Collection of the Leiden Museum (nos. 3062 and 2490, respectively; see Hooije 1955, pp. 15 and 43), further agree with the Israel fragment in the thickness of th ridges plus cement intervals (25–27 mm), in their sinuosity, number of conelets, an posterior narrowing; the resemblance is very close indeed. The full number of plate of M^3 is 10–11 in *S. insignis*, and 10–12 in *S. trigonocephalus* (Hooijer, *loc. cit.* pp 14 and 49). It seems likely therefore, that the Jisr Banāt Yaqūb stegodont carrie the same number of ridges in its last upper molars.

The African species of *Stegodon* as far as known at present are *Stegodon kaisensi* Hopwood (1939), syn. *Stegodon fuchsi* MacInnes (1942) from the Early Pleistocen of Kenya and Uganda, and *Stegodon syrticus* Petrocchi (1954) from the (?) Pliocen of Cyrenaica*. The former species has 6 ridges in M^2 and 8–9 ridges in M^3; th latter has 8 ridges in M^3. The East African stegodont seems to tally well in size wit the Israel stegodont, but is less advanced; in the M^3 from Cyrenaica the 3rd ridg from behind is 122 mm wide at base, and the penultimate ridge 118 mm; *Stegodo syrticus*, therefore, is not only more primitive but also larger than the Israel stegodont

The specimen reported upon in the present paper is the first true *Stegodon* to hav been described from Israel; the earlier record of *Stegodon* sp. from Bethlehem (Gard ner and Bate 1937) is based on a primitive *Archidiskodon* (Hooijer 1958).

The Pliocene and Pleistocene distribution of the genus *Stegodon* as we knew i until now is markedly discontinuous: on the one hand southern and eastern Asi (from India, China and Japan to Java, Flores, Celebes and the Philippines), and o the other hand northern and eastern Africa (Cyrenaica, Kenya and Uganda). Th Israel *Stegodon mediterraneus* nov. spec. forms a link between these two areas o distribution; it marks a point on the route of faunal migration between the tw continents. It must have been rare, at any rate at Jisr Banāt Yaqūb, but in a sens

* South African stegodonts are known to me to have been found; since they have not yet bee described I shall refrain from discussing them here.

it is the most interesting element to the fauna of that site, introducing a new Asiatic migrant form in the Pleistocene fauna of Israel such as *Hemibos palaestinus* Pilgrim (1941) found at Gadera, or *Hipparion* and *Leptobos* found at Bethlehem (Hooijer 1958). Without the *Stegodon*, the fauna from Jisr Banāt Yaqūb consists of elements that would not be out of place in a western European Middle Pleistocene Interglacial fauna, although the *Dama* (represented by a single phalanx) may be the Iranian fallow deer the range of which never extended into Europe. As far as we know at present there were no deer in Israel in the Early Pleistocene, but the fauna of Bethlehem, which is of this age, contains a giraffe that is known in the fossil state only from Africa (Hooijer 1958). The land of Israel, standing as it does at the crossroads of three continents, very likely will prove to yield further interesting faunal links if and when its fossiliferous beds will be further explored.

REFERENCES

1. Gardner, E. W., and Bate, D. M. A., 1937, The bone-bearing beds of Bethlehem: Their fauna and industry, *Nature*, **140**, 431.
2. Hooijer, D. A., 1955, Fossil Proboscidea from the Malay Archipelago and the Punjab, *Zool. Verh. Mus. Leiden*, **28**, 1146.
3. Hooijer, D. A., 1958, An Early Pleistocene mammalian fauna from Bethlehem, *Brit. Mus. (Nat. Hist.), Geol. Bull.*, **3**, 265.
4. Hooijer, D. A., 1960, Fossil mammals from Jisr Banāt Yaqūb, south of Lake Huleh, Israel, *Bull. Research Council of Israel*, **8G**, 177.
5. Hopwood, A. T., 1939, The mammalian fossils, *in* O'Brien, T. P., *The prehistory of Uganda Protectorate*, Cambridge Univ. Press, Cambridge, England, 308–316.
6. MacInnes, D. G., 1942, Mioceneand post-Miocene Proboscidea from East Africa, *Zool. Soc. London Trans.*, **25**, 33.
7. Petrocchi, C., 1954, I proboscidati di Sahabi, *Accad. Naz. dei XL, Rend.* ser. 4, **4–5**, **1**.
8. Pilgrim, G. E., 1941, A fossil skull of *Hemibos* from Palestine, *Annales and Mag. Nat. Hist.*, ser. **11**, **7**, 347.
9. Stekelis, M., 1956, The implementiferous beds of the Jordan Valley, *IV Congr. Internat. Cien. Prehist. y Protohist. Crónica*, (Madrid, 1954), 391, Zaragoza.

Plate I

Stegodon mediterraneus nov. spec., Middle Pleistocene, Jisr Banāt Yaqûb, Israel, fragment of M^3 sin. (holotype); fig. 1, crown view; fig. 2, anterior view; fig. 3, lingual view; fig. 4, posterior view. All figures natural size.

ON THE GEOLOGY OF THE LACHISH AREA, ISRAEL

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ABSTRACT
A geological map on a scale of 1:50,000 has been prepared, following a stratigraphical and structural study of the Lachish area in the foothills region of Judaea. Ten lithological units ranging in age from Eocene through Miocene, have been distinguished. The palaeogeography and tectonics of the region are discussed.

INTRODUCTION

The Lachish area forms a part of the foothills region to the west of the Judaean Mountains (Hebron). It comprises rocky hills, up to 450 m above sea level in the east decreasing to 100 m in the west. Two main wadis, Wadi Saweilim and Wadi Qubeiba, drain the area in an E–W or E–NW direction, following the mild inclination of the strata. The outcropping strata range from Eocene through Quaternary. Most of the chalky outcrops belong to the Eocene. The greater part of the area is covered by "nari", with only a few outcrops. The basis for age determination was provided by micropalaeontological analyses of 350 rock samples.

The scale of the mapping is 1:20,000.

The geology of the region has previously been studied by Blake (1935), Avnimelech (1936), Picard and Solomonica (1936), and Cox (1943).

This study has been carried out for Tahal (Water Planning for Israel) Ltd., Tel Aviv, and has been directed and supervised by Professor L. Picard of the Department of Geology, Hebrew University of Jerusalem.

STRATIGRAPHY

Ten lithological units* are proposed for the area, belonging successively to the Eocene, Oligocene and Miocene. The Eocene strata are subdivided into four stratigraphical units with different assemblages of foraminifera.

(a) Lower Eocene (LE). This outcrops only south of the Lachish area (Golik 1960)

* The columnar section was made in cooperation with A. Golik who has done a similar investigation in the adjoining southern area (see this bulletin, p. 135). As the lithological Units 1, 2 and 3, are found in his area only, they are not mentioned in this text.

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(b) Middle Eocene — lower part (ME I)
(c) Middle Eocene — upper part (ME II)
(d) Upper Eocene (UE)

Lithological Unit 4 (ME I)

This unit outcrops in the centre and southern part of the region. It consist of white-creamy chalk alternating with thin beds, up to 15 cm, of f'inty chalk. Th latter forms continuous layers, or else occurs as brown to white concretions. At th base of this unit flint beds are scarce. In its upper part, there occurs chalky limestone The chalk is stained by limonite. Rounded barite concretions (with 32% $BaSO_4$) u to 10 cm across appear sporadically. The thickness of the unit is about 100 m.

The microfauna is mainly composed of Foraminifera of the families Globigerinidae Uvigerinidae, Globorotaliidae, and of Radiolaria. The age of ME I (middle Eoecne is indicated by the following:

Truncorotalia ex gr. *crassata* (Cushman)
" *aragonensis caucasica* (Glaessner)
" *spinulosa* (Cushman)
Truncorotaloides topilensis (Cushman)
Aragonia aragonesis (Nuttall)
Bulimina forticosta (Finlay)
" *stalacta* (Cushman & Parker)
Globigerina linaperta (Finlay)
"*Gratobuliminella*" *grata* (Parker & Bermudez)
Globigerinoides orbiformis (Cole)
Globorotalia pseudoscitula (Glaessner)

This fauna makes its first appearance in ME I and continues up into ME II. Non of the fossils mentioned disappears at the end of ME I. Therefore, ME I as such i distinguished by the absence of those characteristic fossils which first appear in ME II The lower limit of this unit crops out south of the investigated area (see Golik 1960) The upper limit is not sharply defined but is recognized by the appearance of th marly chalk of lithological Unit 5.

Lithological Unit 5 (ME II)

This unit consists of white to white-creamy marly chalk stained by limonite an sometimes showing green speck. In this unit, too, there occur rounded barite concre tions similar to those described in Unit 4. In its external appearance, this unit is ver similar to Unit 8 (*UE*, see below), from which it differs micropalaeontologically, a well as by the absence of grains of glauconite and apatite, which characterize Unit 8

The lower part of this unit contains a few horizons of flinty chalk and chalky limestone. These gradually disappear upwards. The thickness of this unit is about 100–130 m. It covers most of the area.

The rich fauna consists mainly of Foraminifera (Globorotaliidae, Globigerinidae, Hantkeninidae, and Uvigerinidae) and Radiolaria. The age of ME II (late middle Eocene) is indicated by the following:

Hantkenina (*Aragonella*) sp.
" " *longispina* Cushman.
" (*Aplinella*) *dumblei* Weinz & Applin
Globigerinoides mexicana (Nuttal)
Globorotalia lehneri Cushman & Jarvis
Tritaxilina cubensis Cushman & Bermudez
Cibicidoides libycus (Le Roy)
Turborotalia centralis (Cusman & Bermudez)

Most of the numerous ancient man-made caves in the area have been excavated in this unit. This unit is undoubtedly a major part of the "Beit Jibrin series" (Picard and Solomonica 1936).

Lithological Unit 6 (*UE*)

Unit 6 is a conglomerate of boulders an pebbles cemented by yellow marl. The limey to chalky boulders are of middle to late Eocene age. This unit is easily recognized in its few outcrops, at the south-western side of the mapped aerea, along Wadi Saweilim, near 1306/1040, and at Tur-tani 1322/1031. It should not be confused with the Oligocene conglomerate of Unit 9 (see below). The thickness of the conglomerate is not uniform. It attains 5-6 m. The following families of Foraminifera appear in the matrix:

Hantkeninidae, Globorotaliidae, Globigerinidae,
Uvigerinidae, Bolivinidae, Hyalovirgulinidae.

Late Eocene age of the unit is indicated by the following:

Uvigerina sp.
Turborotalia cerroazulensis (Cole)
Bulimina jacksonensis Cushman
Globigerinatheka sp.
Catapsydrax dissimilis Cushman & Bermudez
Hantkenina (*Hantkeninella*) *primitiva* Cushman & Jarvis
Chiloguembelina spp.
Microglobigerinella micra (Cole)

Grains of glauconite and apatite serve as good markers for this unit. The conglome-

rate rests unconformably upon lithological Unit 5 (ME II) and possibly also on lithological Unit 4 (ME I)

Lithological Unit 7 (*UE*)

This unit consists of light grey to yellow limestone, with a few marly layers. Microfaunal examinations show the age identical with Unit 6 (UE), and thus it may be assumed that these beds as well as the conglomerate (Unit 6) were deposited contemporaneously, yet under different facial conditions. The microfauna alone can show the difference between these beds and those of Unit 10 (Oligocene).

Lithological Unit 8 (*UE*).

This unit consists of white to creamy white marly chalk with grains of glauconite and apatite. A few limestone layers appear as well. The main outcrops are seen in the vicinity of the moshav (settlement) Lachish and on the western side of the mapped area where a few islands emerge from the alluvium (1294/1112).

The lower limit outcrops only in the vicinity of Kh. Er. Rai (1330/1114), where it seems to lay conformably upon Unit 5 (ME II). The age of this unit is late Eocene (see faunal list of Unit 6) and it is probably included in the "Beit Jibrin series" (Picard and Solomonica 1936). The maximun thickness of this unit is 40-50 m.

Lithological Unit 9 (*Oligocene*).

This unit forms the base conglomerate of the Oligocene deposits. It is composed of components which are chalky or limey, with concentrations of clayey material. The pebbles and boulders are cemented by marly chalk, with limonitic stains, dotted with glauconite and apatite. This unit rests unconformably on older beds around the moshav Lachish. Typical outcrops showing clear contact between this conglomerate and the chalk of Upper Eocene (Unit 8) are seen at Tel Lachish; 1655/1090; 13734/11058; 13783/10958; Kh.Er. Rai 1329/1110.This conglomerate resembles the one of Unit 6 (UE), yet in the field it may be recognized by its green patches and its macrofossils. The thickness of this unit is 7–10 m.

The following fossil groups appear throughout this unit.

FORAMINIFERA: Rotaliidae, Lepidocyclinidae, Nummulitidae, Amphisteginidae.

BRYOZOA

LAMELLIBRANCHIATA: Pectinidae.

ECHINOIDEA

Oligocene age is indicated by the following:

Heterostegina sp.	*Spiroplectammina carinata* (d'Orbigny)
Gavelinonion spp.	*Pararotalia viennoti* (Greig)

Operculina spp.	*"Eponides" schreibersi* (d'Orbigny)
Epistominella sp.	*Almaena osnabrugensis* (Münster)
Nummulites spp.	*Sphaeroidina* sp.
Schenckiella sp.	*Lepidocyclina* spp. (*Nephrolepidina* and *Eulepidina*)

Schizaster parkinsoni (Defrance)
Chlamys (*Aequipecten*) *delata* (Michelotti)
Chlamys (*Aequipecten*) *quinquepartita* (Blanckenhorn)

Ostrea sp.	*Cucullaea* sp.
Pecten sp.	
Spondylus sp.	*Crassatellites* (?) sp.

Lithological Unit 10 (Oligocene).

This unit consists of alternations of grey to brownish limestone and marly chalk, dotted with grains of glauconite and apatite. Macrofossils are present. Outcrops are found in the northern part of the mapped area, in the vicinity of the moshav Lachish, where rocks of this unit lie on the conglomerate of Unit 9. The approximate thickness of this unit is 30 m. The grey limestone present in this unit closely resembles the limestone of Unit 7 (UE), and the microfauna alone makes distinction possible. The microfauna indicates Oligocene age (see faunal list of Unit 9).

Lithological Unit 11 (Miocene).

The unit comprises coarse-grained, yellow to orange crystalline limestone. Pebbles are rare. Only two outcrops were recognized, both at 425 m above sea level, resting unconformably on the chalk of Unit 5 (ME II). The following groups of Foraminifera appear throughout: Alveolinidae, Amphisteginidae, Rotaliidae, Elphidiidae, Milliolidae. Miocene age is indicated by the following:

Neoalveolina melo kurdica Reichel
Nonion boueana d'Orbigny
Neoalveolina spp.
Ammonia spp.
Elphidium crispum (Linné)
Cancris sp.
Elphidiononion spp.
Ammonia beccarii (Linné)

Lithological Unit 12 (Miocene).

Unit 12 is a conglomerate of crystalline grey, red, yellow, and white limestone pebbles and of angular to fairly rounded flint pebbles. The cementing material may be chalk converted to "nari". In two places megafossils are abundant: At Sh. Ali (400 m above sea level) and near the moshav Lachis (1354/1090) (240 m above sea level). The conglomerate occurs scattered in the area, generally on the summits of hills, where it lies unconformalby on older rocks. Lithologically, the limestone pebbles resemble the

yellowish crystalline limestone of Unit 11 (Miocene). The age of the unit is Miocen (see microfaunal list of Unit 11). The thickness of this conglomerate is 10–15 m. Th following megafossils were collected:

Arca (*A.*) ? *diluvii* Lamarck
Arca (*A.*) ? *turoniensis* Dujardin
Cardium (*C.*) cf. *paucicostatum* Sowerby
Glycimeris sp. cf. *G.* (*Pectunculus*) *rogeri* Erentöz
Ostrea sp.
Pecten cf. *praebenedictus* Tournouër
Venus sp.
Astraea sp.
Calliostoma (?) sp.
aff. *Strombus antiochensis* Roman
cf. *Vexillum* (*V.*) *plicatula* (Brocchi)
Clypeaster campanulatus Schlotheim
Eupatagus sp.

Lithological Unit 13 (*Miocene*).

This unit composed of sandstone and loose sand, white to yellow in colour occasionally with small rounded pebbles. It outcrops at the altitude of 100 m along Wadi El Mihwar (NW of Kiriath Gath). It lies unconformably on previou layers. The microfauna indicates Miocene age (see faunal list of Unit 11). In additio the sand also contains much older microfaunas. This unit may have been forme by redeposition in the Pliocene (Picard 1943).

PALAEOGEOGRAPHY AND STRUCTURE

In the Middle Eocene, the area under consideration was completely covered by th sea. Deposition was continuous and no considerable changes of facies are recognizable In the Upper Eocene, three different types of rocks were deposited (see Units 6, 7 and 8 the nature of which may be due to differences in facies. Considering their occurrenc in the area we may assume that in that period the region was under the influence o flooded embayments. The conglomerate and limestones were deposited on th margins of the bays, while in their deeper parts chalky sediments were predominant.

As the layers of the Upper Eocene generally rest disconformably upon the layers o the Middle Eocene, it seems that after the Middle Eocene the sea retreated westward and only slight ingressions eastwards occured in late Eocene time. The post-lat Eocene sea continued to retreat further westwards. It ingressed again i Oligocene time, though without reaching as far as its previous eastern shores of lat Eocene. Thus, the shore lines of the late Eocene bays moved westwards in the Olig

ocene. The base conglomerate which underlies the Oligocene indicates the ingression of that sea (similar to Strakey's assumption, *in* Blake 1936).

Our statement that the Oligocene sea reached the bays of late Eocene time is supported by the fact that most of the Oligocene deposits are underlain by the Upper Eocene strata. Yet the smaller extent of the Oligocene bays is apparent from the shallow water facies of Oligocene deposits underlain by deep water chalk of the Upper Eocene.

After the Oligocene the sea retreated to the west but during the Miocene there occurred another invasion probably in three different ingressions. The remnants of the first ingression are found at an altitude of 400–425 m. They consist of yellow crystalline limestone, conglomerates and abundant macrofossils at Sh. Ali (see Units 11 and 12). The second ingression reached only up to the line formed by the recent higher hills (400–450 m). Remains of its deposits are encountered at altitudes of 230–350 m, mainly in the form of conglomerates of limestones and flint pebbles. The evidence of this ingression are the conglomerate pebbles which contain fauna of Miocene age and closely resemble the layer of crystalline limestone found in the first ingression. These pebbles were probably formed by the disintegration of the limestone layer which had been deposited in the first ingression. The third ingression only reached the alluvial region of today. Its sandy deposits are to be found at the altitude of 100 m in Wadi El Mihwar, which may however be of Pliocene time.

The general structure shows a slight west and north-west inclination of the layers (Middle Eocene). The dip is 0.5° to 2°, rarely larger. This general inclination is sometimes disturbed by slight local folds. Some faults may be assumed to be present, but they are probably masked by the uniformity of the chalk and and by "nari".

The main tectonic movement occurred between Middle and Upper Eocene. This is indicated by the change in facies, which up to the end of the Middle Eocene is one of deep water, whereas the younger strata were evidently formed by deposition in a shallow sea. It also seems that the dip of the post-Middle Eocene sediments is less than that of the Middle Eocene. The tectonic movement continued in Oligocene-Neogen times.

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REFERENCES

AVNIMELECH, M., 1936, *Etudes géologiques dans la region de la Shephelah en Palestine*, Grenoble.
AVNIMELECH, M., 1943, Transgressive Upper Eocene in Palestine, *Geol. Mag.*, 80, 107-110.
BLAKE, G. S., 1936, *The stratigraphy of Palestine and its building stones*, Jerusalem.

Cox, L. R., 1943, On the occurrence of the marine Oligocene in Palestine, *Geol. Mag.*, **71**, 377-355.

Davis, A. M., 1935, *Tertiary Faunas*, **1**, Thomas Murby & Co., London.

Golik, A., 1960, On the geology of Ziklag Area, Israel, *Bull. Research Council of Israel*, **9G**, 129–134.

Picard, L., 1943, *Structure and evolution of Palestine*, Jerusalem.

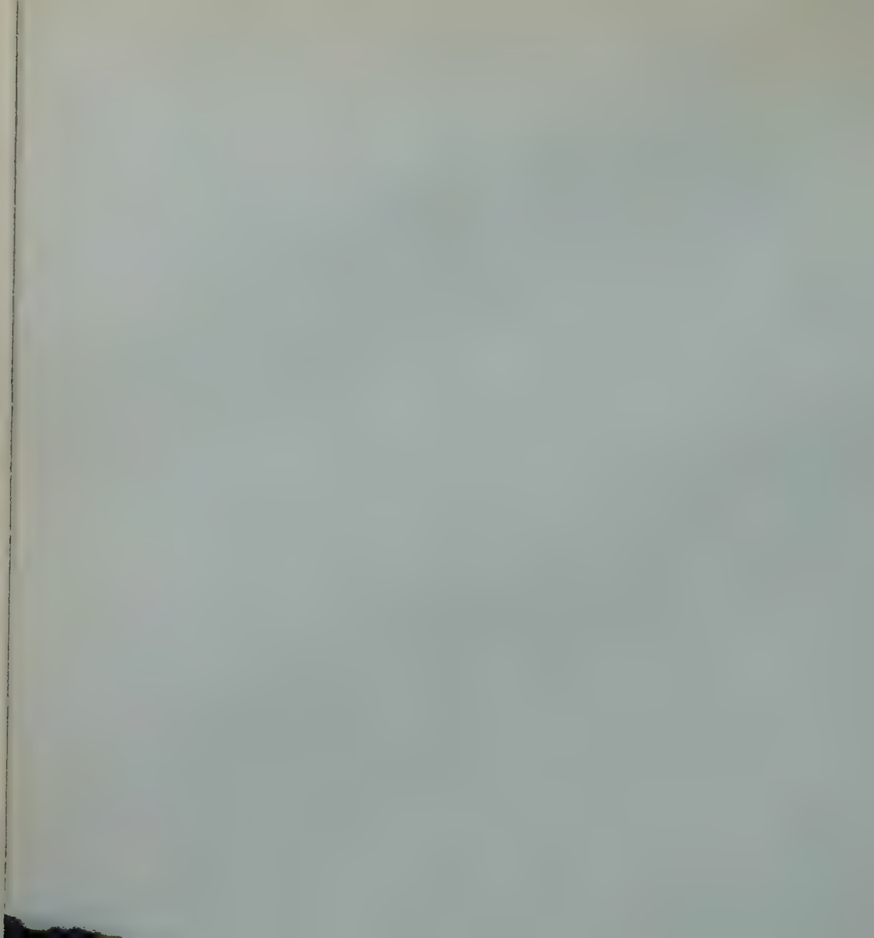
Picard, L., 1959, Geology and oil exploration of Israel, *Bull. Research Council of Israel*, **8G**, no. 1, 1-30.

Picard, L., and Avnimelech, M.,1937, On the geology of the Central Coastal Plain, *Geol. Dept. Hebrew Univ. Bull.*, **1**, no. 4, (*Palestine Orient. Soc. Jour.*, **16**, Jerusalem).

Picard, L., and Solomonica, P., 1936, On the geology of the Gaza–Beersheba district, *Geol. Dept. Hebrew Univ. Bull.*, **1**, no. 2, (*Palestine Orient. Soc. Jour.*, **17**, Jerusalem).

Reiss, Z., 1952, On the Upper Cretaceous and Lower Tertiary microfaunas of Israel, *Bull. Research Council of Israel*, **2**, 37-50.

GEOLOGICAL MAP OF THE LACHISH AREA
SCALE 1:50,000
Prepared by YESHAYAHU GREITZER
LEGEND
Al Alluvium
Mi Miocene
Oli Oligocene
UE Upper Eocene
ME II Middle Eocene, Upper part
ME I Middle Eocene, Lower part
dip
estimated fault
road
wadi
NECHUSHA
KIRIAT GAT
NOAM
SHALVA
ACHUSAM
LAHISH
Tell Lachish
AMATZIA
Kh fatata
To Beersheba
REFERENCE MAP
TEL AVIV
JERUSALEM
ASHQELON
BEERSHEBA

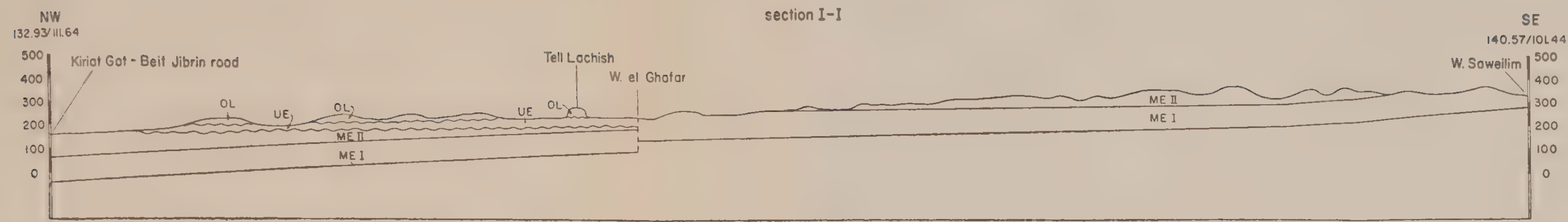


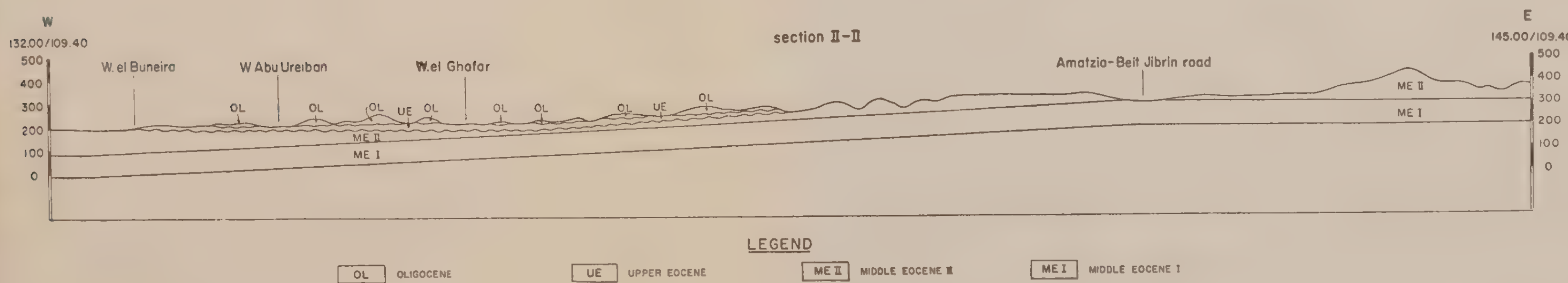
GEOLOGICAL CROSS-SECTIONS

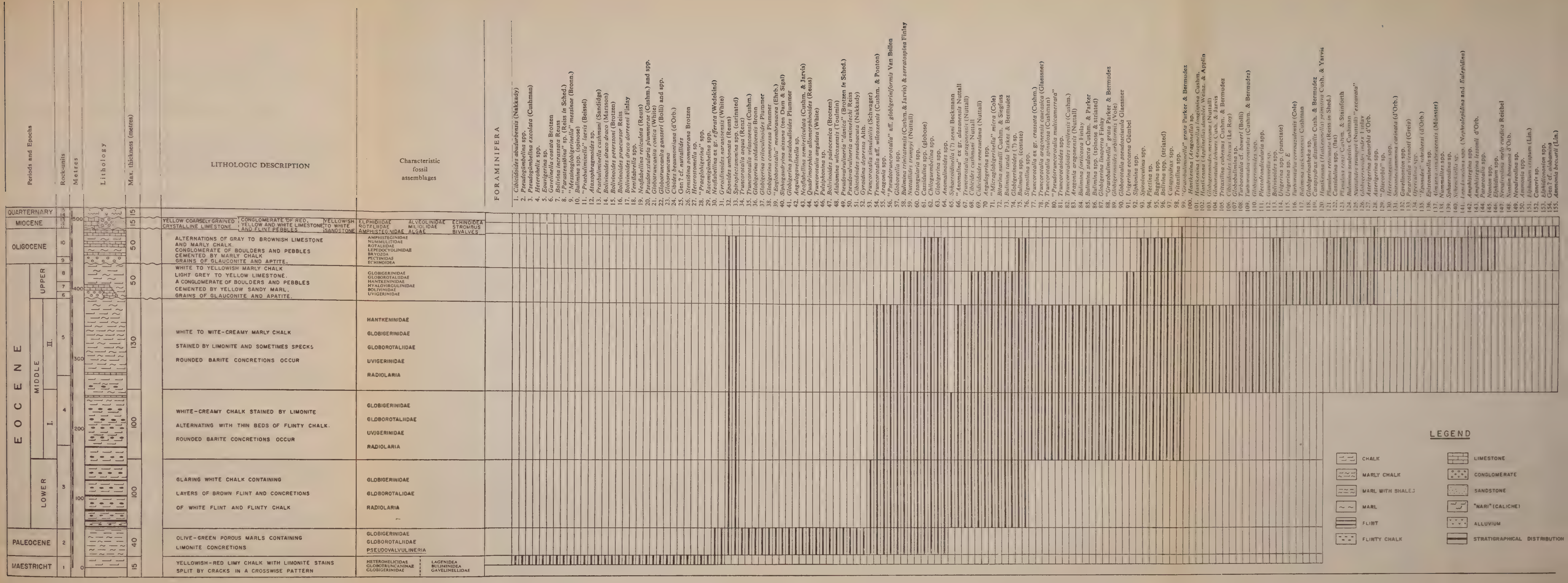
LACHISH AREA

SCALE : vertical 1:25,000
horizontal 1:50,000

By Y. GREITZER







Periods and Epochs
Rock-units
Metres
Lithology
Max. thickness (metres)
LITHOLOGIC DESCRIPTION
Characteristic fossil assemblages
FORAMINIFERA
QUARTERNARY
MIOCENE
OLIGOCENE
EOCENE
UPPER
MIDDLE
LOWER
II.
I.
PALEOCENE
MAESTRICHT
YELLOW COARSELY GRAINED CRYSTALLINE LIMESTONE
CONGLOMERATE OF RED, YELLOW AND WHITE LIMESTONE AND FLINT PEBBLES
YELLOWISH TO WHITE SANDSTONE
ELPHIDIIDAE ROTALIIDAE AMPHISTEGINIDAE
ALVEOLINIDAE MILIOLIDAE ALGAE
ECHINOIDEA STROMBUS BIVALVES
ALTERNATIONS OF GRAY TO BROWNISH LIMESTONE AND MARLY CHALK.
CONGLOMERATE OF BOULDERS AND PEBBLES CEMENTED BY MARLY CHALK
GRAINS OF GLAUCONITE AND APTITE.
AMPHISTEGINIDAE NUMMULITIDAE ROTALIIDAE LEPEDOCYCLINIDAE BRYOZOA PECTINIDAE ECHINOIDEA
WHITE TO YELLOWISH MARLY CHALK
LIGHT GREY TO YELLOW LIMESTONE.
A CONGLOMERATE OF BOULDERS AND PEBBLES CEMENTED BY YELLOW SANDY MARL.
GRAINS OF GLAUCONITE AND APATITE.
GLOBIGERINIDAE GLOBOROTALIIDAE HANTKENINIDAE HYALOVIRGULINIDAE BOLIVINIDAE UVIGERINIDAE
WHITE TO WITE-CREAMY MARLY CHALK
STAINED BY LIMONITE AND SOMETIMES SPECKS
ROUNDED BARITE CONCRETIONS OCCUR
HANTKENINIDAE
GLOBIGERINIDAE
GLOBOROTALIIDAE
UVIGERINIDAE
RADIOLARIA
WHITE-CREAMY CHALK STAINED BY LIMONITE
ALTERNATING WITH THIN BEDS OF FLINTY CHALK.
ROUNDED BARITE CONCRETIONS OCCUR
GLOBIGERINIDAE
GLOBOROTALIIDAE
UVIGERINIDAE
RADIOLARIA
GLARING WHITE CHALK CONTAINING
LAYERS OF BROWN FLINT AND CONCRETIONS
OF WHITE FLINT AND FLINTY CHALK
GLOBIGERINIDAE
GLOBOROTALIIDAE
RADIOLARIA
OLIVE-GREEN POROUS MARLS CONTAINING
LIMONITE CONCRETIONS
GLOBIGERINIDAE
GLOBOROTALIIDAE
PSEUDOVALVULINERIA
YELLOWISH-RED LIMY CHALK WITH LIMONITE STAINS
SPLIT BY CRACKS IN A CROSSWISE PATTERN
HETEROHELICIDAE GLOBOTRUNCANINAE GLOBIGERINIDAE
LAGENIDEA BULIMINIDEA GAVELINELLIDAE
LEGEND
CHALK
MARLY CHALK
MARL WITH SHALES
MARL
FLINT
FLINTY CHALK
LIMESTONE
CONGLOMERATE
SANDSTONE
"NARI" (CALICHE)
ALLUVIUM
STRATIGRAPHICAL DISTRIBUTION

ON THE GEOLOGY OF THE ZIKLAG AREA, ISRAEL

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ABSTRACT

The report contains a study on the geology and stratigraphy of the Ziklag area on the downslopes of the Hebron mountains. Nine lithological units are distinguished, ranging in age from Maestrichtian to Miocene. A geological map of the area, at 1:50,000, is given The history of the geological events and the tectonics of the area are explained.

INTRODUCTION

The area investigated is situated near the Israel-Jordan border, about 20 km north of Beersheba, and includes the settlements of Ziklag and Dv'r. The landscape of the area is one of rocky hills, reaching 475 m in the east and decreasing to 200 m in the west. Most of the wadis run an east-west direction, yet geomorphological conditions cause some of the wadis (W. Kelekh and W. Shikma) to change their courses towards the north, before reverting to an east-west direction.

The outcropping rocks are successively of Maestrichtian, Paleocene, Eocene and Miocene ages. They form the eastern margins of a synclinorium which extends between the Hebron anticline on the east, and the Heletz anticline on the west (see cross-section, Picard 1959, Figure 1).

A geological map on the scale of 1:20,000 was prepared. For this purpose, more than 300 micropaleontological examinations were carried out. Earlier work in this area is due to Blake (1936) and Picard and Solomonica (1936).

The present work has been prepared for Tahal (Water Planning for Israel) Co., Tel Aviv, and has been directed and supervised by Professor L. Picard, of the Department of Geology, The Hebrew University of Jerusalem.

LITHOLOGICAL UNITS*)

Nine lithological units are recognized in the mapped area.

Lithological Unit No. 1 (Ma).

This unit consists of soft limey chalk with limonite stains which give it a yellowish-red colour. The rock is split by cracks in a crosswise pattern. The unit resembles the lower part of the "*Couches de Sar'a*" (Avnimelech 1936; Reiss 1955). The age indicated by the following fossils is late Maestrichtian:

* The complete columnar section has been prepared in collaboration with Y. Greitzer, working on the adjacent Lachish area (Greitzer 1960). Because of this, some of the lithological units mentioned in the columnar section do not occur in the area described here and so the unit numbers are not always successive.

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Pseudoguembelina spp.
Pseudoguembelina exolate (Cushman)
Bolivina incrassata (Reuss)
Bolivinoides draco draco (Marson)
B. peterssoni (Brotzen)
B. draco dorreeni (Finlay)
B. praecursor(Reiss)
Globotruncanita conica (White)
G. gansseri (Bolli) and *G.* spp.
Globotruncana spp.
Stensiöina pommerana Brotzen

Two faunal facies are discerned in this unit. The western facies is rich in pelagic Foraminifera (Globorotaliidae, Heterohelicidae). The other occurring more to the East, does not contain any pelagic fauna. The importance of this distribution is explained later. Only the upper 15 m of this unit are exposed. In the water well Dvir 1 in the western part of the area, this unit attains a thickness of 80 m.

Lithological Unit No. 2 (Pal).

Overlying Unit 1 there occur olive-green porous marls containing spherical limonite concretions, which may attain a diameter of 10 cm. The fauna is rich with pelagic Foraminifera and includes:
Truncorotalia aequa (Renz)
Truncorotalia velascoensis (Cushman)
Truncorotalia simulatilis (Schwager)
Globigerina triloculinoides (Plummer)
"*Eogloborotalia*" *membranacea* (Ehrb.)
Neoflabellina semireticulata (Cushman & Jarvis)
Bolivinoides paleocenica (Brotzen)
Pseudovalvulineria "*danica*" (Brotzen *in* Scheduel)
Pseudovalvulineria avnimelechi Reiss

This assemblage points to late Paleocene (Landenian) age and Unit 2 therefore lies unconformably on Unit 1 as there are no Danian strata on the surface of the region. However, rocks of Danian age have been penetrated by the "Dvir 1" water well.

Unit 2 resembles the upper part of the "*Couches Inferieures de Sar'a*" (Avnimelech 1936; Reiss 1955), and the "*Taqiya marls*" (Shaw 1947; Reiss 1955). It occurs mainly in the south-eastern part of the mapped area, in the vicinity of Kh. Zaak and Kh. Budgush.

As the upper and the lower contacts are both indistinct, it is difficult to determine the thickness of this unit. However, it seems that it is not uniform, since a thickness of 25 m has been observed at the eastern border, 30 m somewhat westwards and 70 m in the Dvir 1 water well in the west.

Lithological Unit No. 3 (LE).

Lying conformably on Unit 2, this unit consists of glaring white chalk of microscopic crystalline calcite grains. It contains many layers of brown flint, which may attain 30 cm of thickness. Concretions of flint or flinty chalk appear as well. The thickness and the frequency of the flint layers decrease upwards where the sequence gradually passes into Unit 4.

This unit corresponds to the upper part of the "*Couches de Sar'a*"(Avnimelech 1936; Reiss 1955) and is of early Eocene age. The thickness seems to be irregular. It is estimated at less than 100 m from surface sections, the Dvir 1 water well shows 160 m and other drillings to the north of the area show thickness of 50-60 m. Unit 3 is found in the southern part of the region, in the vicinity of Ziklag and somewhat northwards in the sorroundings of Kh. Murran.

Lithological Unit No. 4 (ME I).

Lying conformably on Unit 3, this unit consists of white chalk and layers of flinty chalk concretions. In the lower part there occur flint layers, as in Unit 3. Both flint and flinty chalk decrease upwards, so that the upper part consists almos completly of white marly chalk. This unit corresponds at least, to a part of the "*Beit Jibrin series*" (Picard and Solomonica 1936). Of particular interest is the occurrence of barite spheric tions in the chalk, which contains 31.98% of $BaSO_4$ and may attain a diameter of 10 cm. The following fauna indicates an early Middle Eocene age:

Truncorotalia ex. gr. *crassata* (Cushman)
Truncorotalia spinulosa (Cushman)
Truncorotalcides topilensis (Cushman)
Globigerinoides orbiformis (Cole)

This unit covers most of the mapped area, mainly occurs in its central and northern parts. Its thickness is estimated at 75–100 m.

Lithological Unit No. 5 (ME II).

Unit 5 consists of soft marly chalk, creamy-whitish in colour. It is linked to the upper part of Unit 4 by a zone of gradual transition. Barite concretions are still found but are rare. The unit corresponds to a part of the "*Beit Jibrin series*" (Picard and Solomonica 1936). It is marked by the abundance of various microfossils. The following fossils indicate a late Middle Eocene age:

Hantkenina (Aragonella) sp.
Hantkenina (Aragonella) longispina (Cushman)

Because of its few outcrops and the eroded upper contact it is not possible to determine the thickness of this unit. Data from area further north show a maximun thickess of 130 m (Greitzer 1960).

Lithological Unit No. 6 (UE).

This unit generally lies unconformably on Unit 4. It is composed of a conglomerate of big boulders cemented by yellowish-brown sandy marl, which contains grains of

glauconite and apatite.The boulders of chalk or limestone may attain a diameter of 75 cm. The age of the boulders is in most cases late Eocene, but middle Eocene is indicated in some of them. The cementing material contains the following fauna, which indicate late Eocene age:

Turborotalia cf. *boweri* (Bolli)
Turborotalia centralis (Cushman & Bermudez)
Turborotalia cerroazulensis (Cole)
Bulimina jacksonensis (Cushman)
Hantkenina (*Hantkeninella*) *primitiva* (Cushman & Jarvis)
Catapsydrax dissimilis Cushman & Bermudez

Incomplete section attains a thickness of 3 m.

Lithological Unit No. 8 (*UE*).

The base of this unit is not exposed, yet it may be assumed that it lies on Unit 6, as its age is late Eocene. Its occurrence is limited to a few outcrops in Wadi Shikma in the western part of the area. It consists of yellowish marly chalky limestone which contains grains of glauconite and apatite. In one place, at the top of this unit there occurs an horizon of finely laminated hard limestone with the general aspect of a lenticule. The fauna is the same as in Unit 6, of late Eocene age.

It is noteworthy that the Oligocene sediments do not crop out in this area, presumably because during Oligocene time the sea retreated well to the west.

Lithological Unit No. 12 (*Mi*).

This unit is a conglomerate composed of pebbles of Senonian and Eocene flint as well as Miocene red and yellow crystalline limestone, cemented by "nari"(caliche). This conglomerate may rest upon any of the units hitherto described. It appears on the tops of the hills at two altitudes, the one at 300–325 m and the other at 475 m above sea level.

The fauna found in the pebbles of Miocene limestone consists of:

Asterigerina spp.
Amphistegina spp.
Elphidium spp.
Elphidium crispum (Linné)
Neoalveolina spp.
Neoalveolina melo courdica Reichel
Ammonia spp.
Ammonia beccarii (Linné)

Lithological Unit No. 13 (*Mi*).

The unit occurs only in the western part of the area. It is composed of white sandstone lying unconformably on Unit 7, filling former physiographical depressions, such as bays, streams and channels. It contains the same Miocene fauna as Unit 12. Picard regards this unit as of Pliocene age (Picard 1943).

GEOLOGICAL HISTORY

The oldest sediments which outcrop in this area are of Maestrichtian age. The Maestrichtian sequence contains two faunal types — pelagic and bentonic (see Unit 1). The bentonic fauna is found in the eastern side of the area, and shows coastal environments. The same fauna, including pelagic specimens, occurs in the western part. It is thus obvious, that the Maestrichtian sea was shallow to the east and open and deep to the west.

Danian deposits were revealed in the west, in the Dvir 1 water well, but have not been found on the eastern side. This may be explained by assuming that in that period the eastern part of the area was higher and above sea level, while the western part was low and submerged. This assumption is confirmed by the unconformity between the Palaeocene and Maestrichtian sediments of the area.

In the Palaeocene the sea invaded the whole area, which remained under sea also during early and middle Eocene. Between middle and late Eocene the sea receded. This is indicated by the big boulders of late Eocene age, as both the boulders and the cementing material bear evidence of the same age. Further indication is provided by the glauconite and apatite grains which are indicative of nearness to the shore lines. The regression continued during the Oligocene, as shown by the fact that Oligocene deposits are confined to the west of the area.

In Miocene time there was a new transgression to the east. Its remnants are conglomerates now found at the altitude of 475 m. Later regression and transgression also left conglomerates which are found at the altitude of 300–325 m. The sandstones which fill bays and depressions are evidence of the last regression.

STRUCTURE

The Judean anticlinorium passes westwards into a big synclinorium, with its axis directed from the north to south. This synclinorium shows relatively small undulations or waves, parallel to the N-S axis. The plunging of the synclinorium is enforced by steps which lead down to the west, each parallel to the structural axis. Only the southern part of the mapped area is influenced by the neighbourhood of the big anticlinorium. This anticlinorium sends a small structural nose, forming a small anticline in the vicinity of Kh. Zaak, with its axis bearing a WSW-ENE direction.

This anticline causes the strata of early Eocene age near Kh. Murran, to be lifted and exposed. Further to the west, the strata are horizontal.

The western part of the area under discussoin, along the line connecting Kh. Mekhaz and Tel-A-Mu'icha, probably shows an additional bending down to the syncline as indicated by the absence of deposits of late Eocene age to the east of this line, whereas drills to the west of the line show considerable thickening of the Upper Eocene deposits.

Some faults were discerned in the area, mostly concentrating in the surroundings of the Kh. Zaak anticline. The majority run from east to west with a throw of about 30 m. They occurred some time after Lower Eocene.

The wedging out of Danian deposits towards the east calls for pre-Danian age the tectonic activity. This activity initiated the formation of the Kh. Zaak anticli resulting in its main upheaval between early Eocene and Miocene times, as shown the fact that Lower Eocene strata are inclined while the nearby Miocene strata, Tel-Ziklag, are horizontal.

ACKNOWLEDGEMENTS

The author wishes to express his gratitude to Prof. L. Picard, under whose sup vision this work was done, to Mr. Z. Reiss, for guiding him in micropalaeontolo Dr. A. Parness and Mr. G. Gill for help in the preparation of the English text, to t Tahal Co. for the financial support which has made this study possible, and members of its staff for their generous assistance.

REFERENCES

Avnimelech, M., 1936, *Etudes géologiques dans la region de la Shephelah en Palestine*, Grenoble.

Avnimelech, M., 1943, Transgressive Upper Eocene in Palestine, *Geol. Mag.*, **80**, 107-110

Blake, G. S., 1936, *The stratigraphy of Palestine and its building stones*, Jerusalem.

Greitzer, Y., 1960, On the geology of Lachish Area, *Bull. Research Council of Israel*, 109–116.

Picard, L., and Solomonica, P., 1936, On the geology of the Gaza–Beersheba district, *G Dept. Hebrew Univ. Bull.*, **1**, no. 2, (*Palestne Orient. Soc. Jour.*, **16**, Jerusalem).

Picard, L., and Avnimelech, M., 1937, On the geology of the Central Costal Plain, *G Dept. Hebrew Univ. Bull.*, **1**, no. 4, (*Palestine Orient. Soc. Jour.*, **17**, Jerusalem).

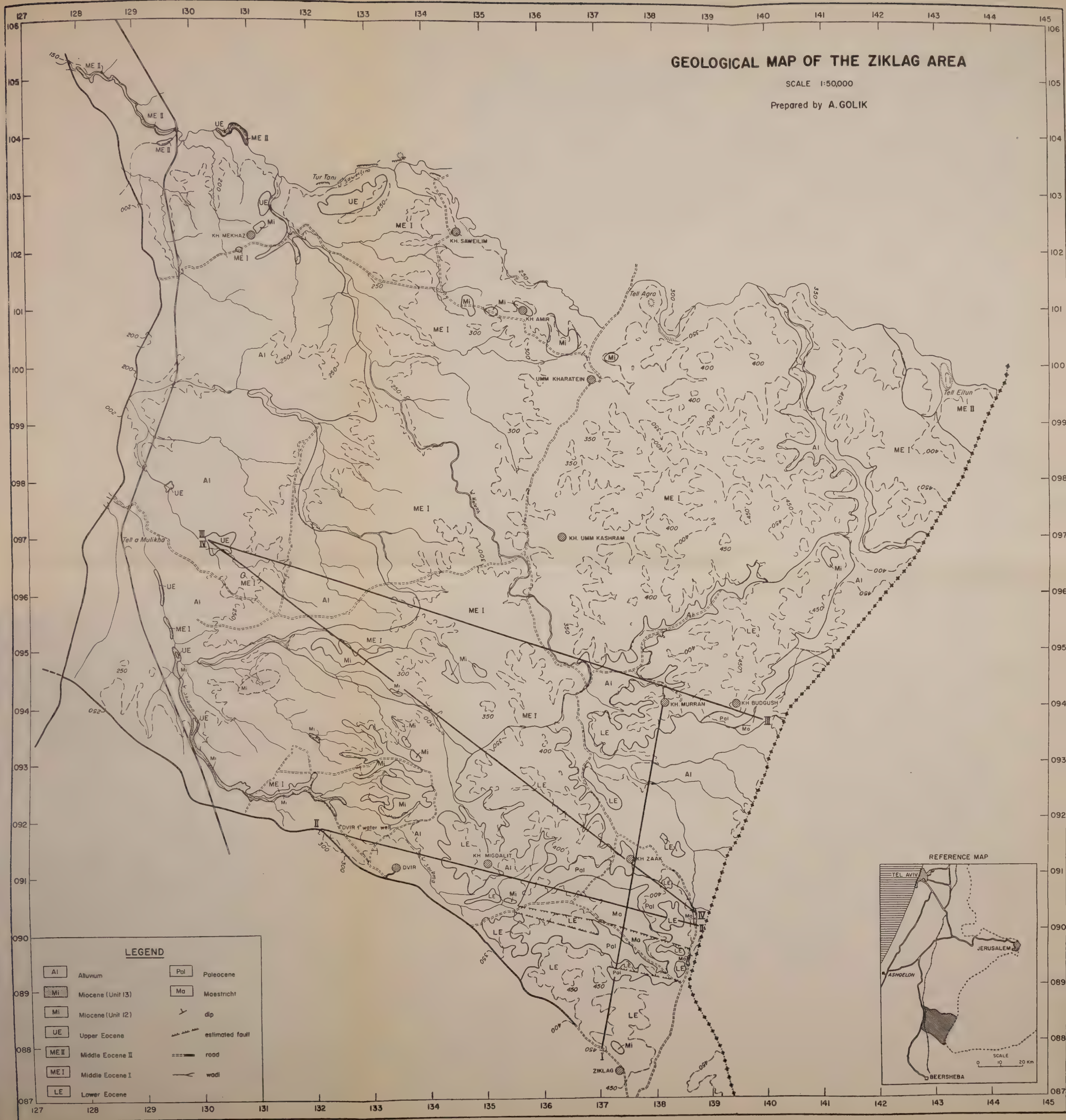
Picard, L., 1943, *Structure and evolution of Palestine*, Jerusalem.

Picard, L., 1959, Geology and oil exploration of Israel, *Bull. Research Council of Israel*, no. 1., 1-30.

Reiss, Z., 1952, On the Upper Cretaceous and Lower Tertiary microfaunas of Israel, *B Research Council of Israel*, **2**, 37-50.

Reiss, Z., 1955, Remarks on the age of some late Cretaceous and early Tertiary stratigraphic u of Israel, *Bull. Research Council of Israel*, **5B**, 121-126.

Shaw, S. H., 1947, *Southern Palestine*, Geological map on a scale of 1:250,000 with exp natory notes, *Governmental Printer*, Jerusalem.



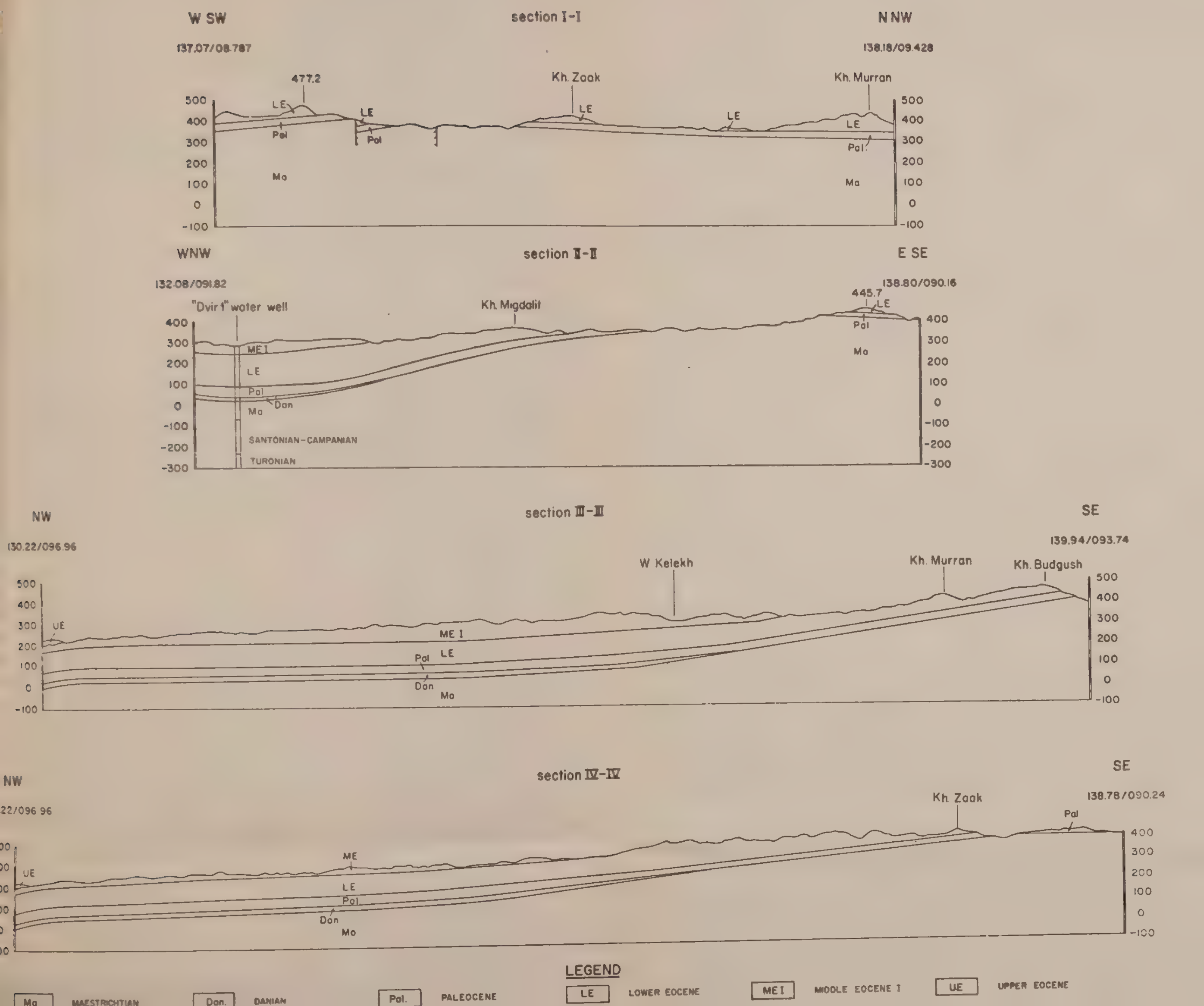
GEOLOGICAL MAP OF THE ZIKLAG AREA
SCALE 1:50,000
Prepared by A. GOLIK
LEGEND
Al Alluvium
Mi Miocene (Unit 13)
Mi Miocene (Unit 12)
UE Upper Eocene
ME II Middle Eocene II
ME I Middle Eocene I
LE Lower Eocene
Pal Paleocene
Ma Maestricht
dip
estimated fault
road
wadi
REFERENCE MAP
TEL AVIV
JERUSALEM
ASHQELON
BEERSHEBA
SCALE
0 10 20 Km
KH MEKHAZ
KH. SAWEILIM
Tur Tani
KH AMIR
Tell Agra
UMM KHARATEIN
Tell Eitun
KH. UMM KASHRAM
Tell a Mulikha
KH. MURRAN
KH BUDGUSH
DVIR 1 water well
DVIR
KH MIGDALIT
KH ZAAK
ZIKLAG

GEOLOGICAL CROSS-SECTIONS

ZIKLAG AREA

SCALE: vertical 1:25,000
horizontal 1:50,000

By A. GOLIK



FOSSIL SOLUTION BASINS IN KURKAR NEAR NATHANYA

EMANUEL MAZOR
Israel Atomic Energy Commission

ABSTRACT

A number of small circular basins were uncovered near Nathanya in a kurkar layer overlain by hamra soil which is rich in Mesolithic flint implements. Comparison with solution basins being formed on the present day coast suggests that the basins at Nathanya might be traces of a Pre-Mesolithic shore. The evidence indicates that hamra was transported to the site and not formed *in situ* by weathering of kurkar.

INTRODUCTION

A group of small basins or "pot holes" was found near Nathanya on the top of a near surface kurkar sandstone which was covered by a layer of red hamra soil. The place is situated on a ridge east of Nathanya, by the ruins of the Arab village Um-Khaled (coordinates 1375/1925), 2 km east of the shore and about 30 m above sea level. The location is well known for its richness in Mesolithic flint implements, usually embedded in the hamra red sand which covers the area.

The first basins were uncovered in the course of public road works and during construction of the new post office building. Since the place was known as a prehistoric site, it was first thought that the basins were artifacts. This led Dr. Berger of the Department of Antiquities to undertake systematic excavations during which he discovered a large number of excellently preserved basins of varying size and form. The basins were subsequently examined by the author and in the present report an attempt is made to explain their origin.

DESCRIPTION

The geological section of the site is shown in Figure 1. The form of the basins is usually round with small irregularities and with rough and unpolished walls. The diameter varies from a few cm to a few tens of cm and the depth is nearly equal to the diameter. In some cases a few basins are connected, the walls between them having disappeared. Various stages of development can be seen in the growth of a number of such connected basins. The resulting one assumes again a rounded from (Plates 1 and 2).

On Plate 3 it is clearly seen that the hamra soil, which covers the kurkar, has filled in the basins, while the contact of the greyish calcareous sandstone with the red soil remained sharp and unaltered. Flint implements were found sporadically distributed in the soil filling the basins, but only in those located close to the surface, apparently washed into them from the hamra above. Basins covered by a peeper layer of hamra

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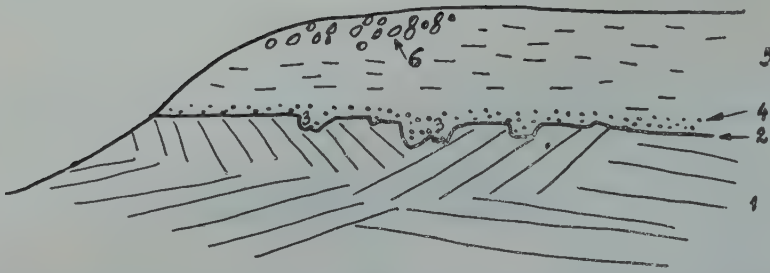

Figure 1
Schematic cross-section. (1) Cross-bedded kurkar (semi-consolidated calcareous sandstone (2) The ancient surface of the kurfar with irregularities caused by the solution basins (3 (4) Reddish sand (about 15 cm) passing upwards into (5) red hamra sand (at least 2 m (6) Alluvium.
Part of the section is seen in Plate 3.

were devoid of implements, thus indicating that no relation exists between th basins and Mesolithic men who left their implements in the hamra.

INTERPRETATION

An attempt was made to find out whether the basins could be the product o some geological process, but at this site no additional data illuminating th problem were found. O

Plate 1
Basins of varying size foun in the excavation near Nat anya. Marks on the stick i the upper part of the phot are at 10 cm intervals.

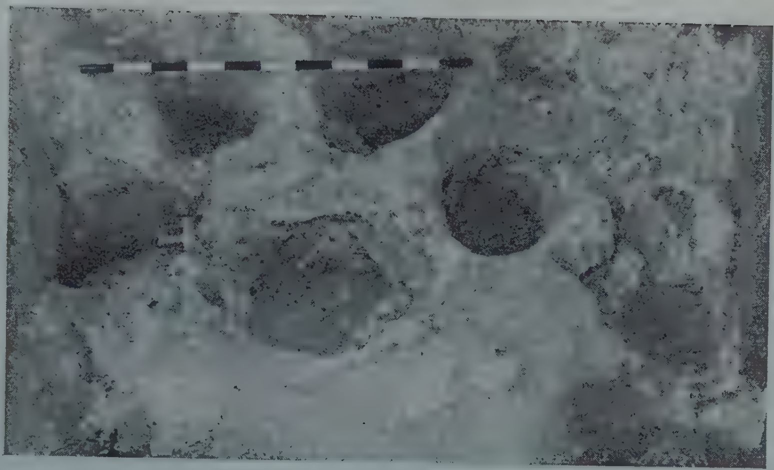

Plate 2
Basins showing rough walls and rounded form.

Plate 3
A section of the excavation. The upper layer is part of surface alluvium and below it reddish hamra fills in the basins of the white kurkar. The contact of kurkar with hamra is very sharply defined and the walls of the basins are seen to be vertical.

the other hand, an answer might be found by comparison with similar phenomena as seen manifested on the present day shore lines. On several places along the beach it is possible to see how basins are developing on kurkar surfaces in tidal areas, as shown, for example, in plates 4 and 5 from the shore at Dor (coordinates 1375/1925). These basins resemble in every respect those found near Nathanya. It seems that the basins

at Dor are formed by solution of the calcareous cement and by washing out of the loosened sand grains. The process was studied and exellently described by Emery (1946), who introduced the term "solution basins" for this occurrence. When the solution basins reache a size of about ten cm a mechanical process also becomes significant. Pebbles which become entrapped in the basins act under the influence o

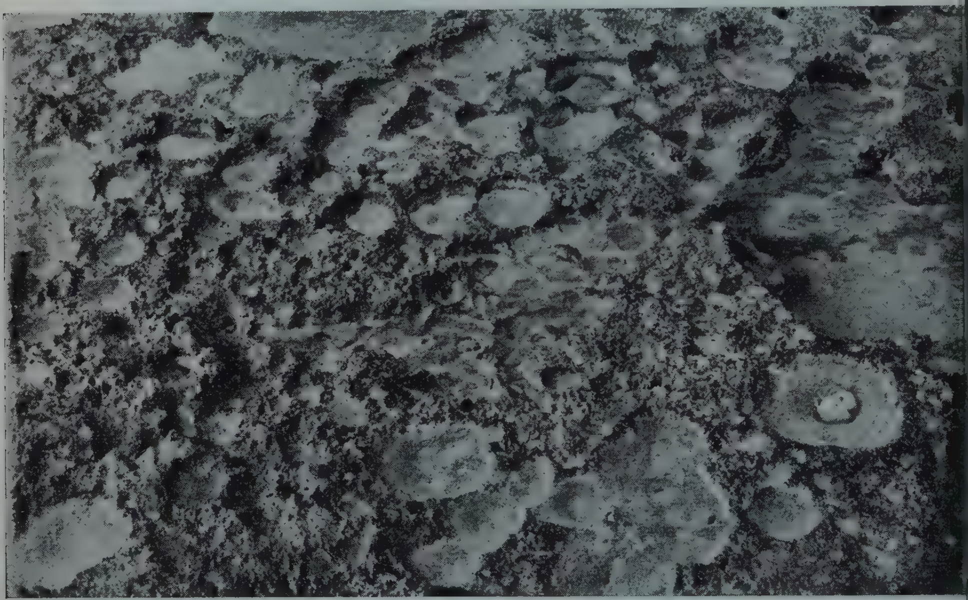

Plate 4
General view of solution basins as developed at the recent beach at Dor (South of Haifa).

the waves as grinding stones (Plate 5), thus enhancing the growth of the basin Solution basins have been found on many beaches all over the world, as described by Emery (1946) and in the extensive literature cited by him.

The marked resemblance of the basins at Nathanya to those at Dor and other places along the present day coast line suggests that the basins at Nathanya indicate an ancient shore line. At the site of the excavations no additional indication of a beach was found, such as fossil snails or pebbles. However, faunal sterility is characteristic also for the area of solution basins at Dor which is situated some distance from the sea. Apparently the retreating sea cleans out pebbles and snails from the basins Thus it might be that our site, which is today 2 km east of the coast line and 30 m above sea level, was an ancient shore which subsequent to the retreat of the sea allowed the hamra to advance from adjacent areas and to cover the kurkar, thereby preserving the basins.

Plate 5
Detailed view of some recent solution basins at Dor.

DISCUSSION AND SUMMARY

The occurrence of solution basins at Nathanya sheds light on the question of genetic relationship between hamra and kurkar. Some investigators are of the opinion that hamra sand is the product of *in situ* weathering of kurkar sandstone (Ravikovitch 1950) while others concluded that it was formed simultaneously with the kurkar as the result of an aeolain sorting process (Rim 1951). The situation at the site under discussion clearly favours the conclusion that the hamra was formed independently and subsequently transported to cover the kurkar, since otherwise the basins could not have been so well preserved, nor could the border line between the kurkar and hamra have become so sharply defined.

Solution basins are well known on recent beaches throughout the world but the unique feature of the basins at Nathanya is that they are fossil. These basins provide evidence that the sea extended a few km to the east of its present line in Pre-Mesolithic times and later retreated. Meanwhile the new coastal area rose about 30 m relative to the present sea level. The old beach was subsequently covered by hamra transported from adjacent areas.

ACKNOWLEDGEMENTS

The author wishes to express his thanks to Dr. F. Berger for his invitation to visit the excavations, and to Dr. Dan H. Yaalon and Mr. Y. Itzhaki for their informative remarks.

REFERENCES

1. Emery, K. O., 1946, Marine solution basins, *Jour. Geology*, **54**, 209-228.
2. Ravikovitch, S., 1950, The brown-red sandy soils of the Sharon and the Shephela, *Agricult. Research Sta. Rehovot Bull.*, **55**, 39 pp.
3. Rim, M., 1951, The influence of geophysical processes on the stratification of sandy soils, *Jour. Soil Sci.*, **2**, 188-195.

LETTER TO THE EDITOR

Type sections of three formations in Western Galilee, R. Freund, *Department of Geology, The Hebrew University of Jerusalem.*

The type sections of the Yanuch formation, Yirka formation and Kishk limestone are presented here*. The latter includes the "Stylolites" formation as its upper member, t_3. The formations were fully described in an earlier paper by Freund (1959, pp. 44-46).

The lower boundary of the Yanuch formation is marked by the appearance of coarse crystalline white limestones instead of chalks and flints. The boundary between the Yanuch and Yirka formations is determined by the Lower Turonian ammonites, the lithological differences being usually insignificant. The beginning of the Kishk limestone is marked by the hard coarse detritic yellow limestones which overlie the soft beds of the Yirka formation, and its end by the white chalks of the Senonian.

The type sections of the "lateral sections" formations are not given, as these are developed better outside the investigated area. Type sections of these formations have previously been prepared by U. Golani of the Department of Geology, Hebrew University, and will shortly be published. Thus the names which were used in the above mentioned work should be invalidated. The Senonian formations are best developed in the Safad area. As Tufaniya chalk is actually a chalky facies of the Peqi'in formation, its name should be omitted too.

The outcrop map of the Yirka formation was prepared after further mapping and investigations of this formation in 1959–60. The distribution of the other two formations is very similar. It was further found that the Yirka formation wedges out against the middle of Rosh Tsurim dolomites, and thus the age of the latter ranges from late Cenomanian to late Turonian.

REFERENCE

1. Freund, R., 1959, On the stratigraphy and tectonics of Upper Cretaceous in Western Galilee *Bull. Research Council of Israel,* **8G**, 43-50, maps.

* The samples are kept in the geological collection of The Hebrew University of Jerusalem.

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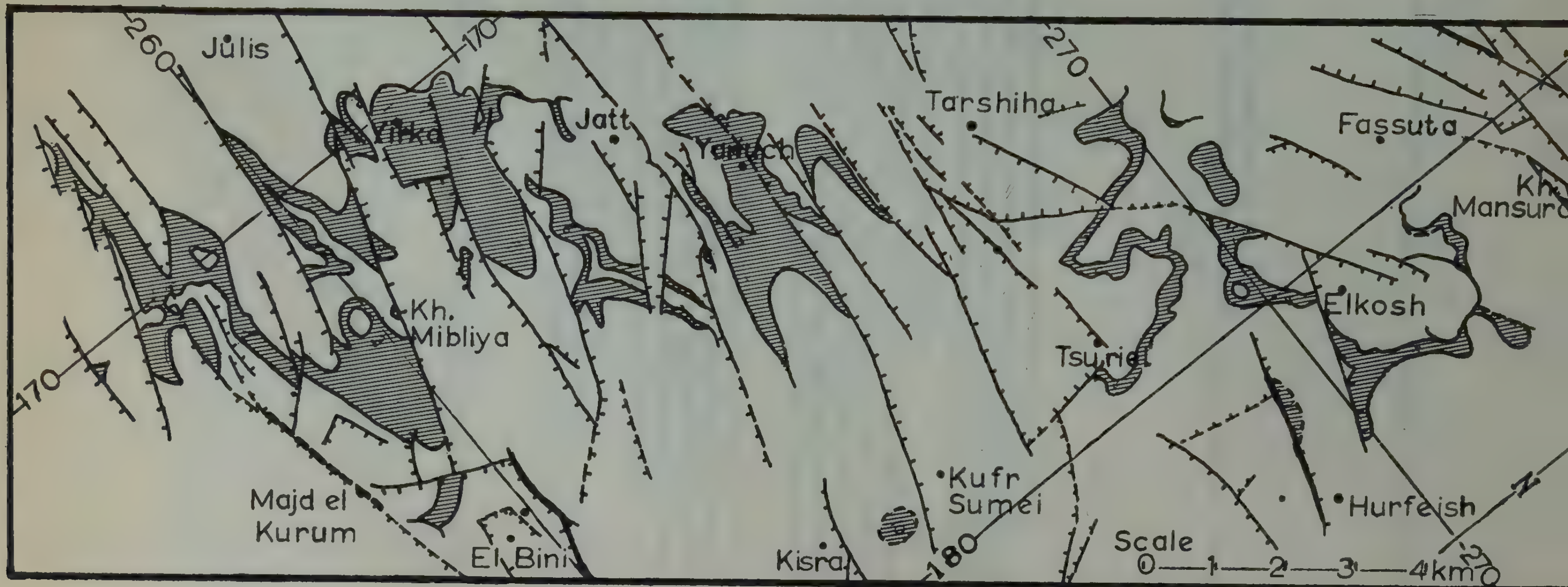
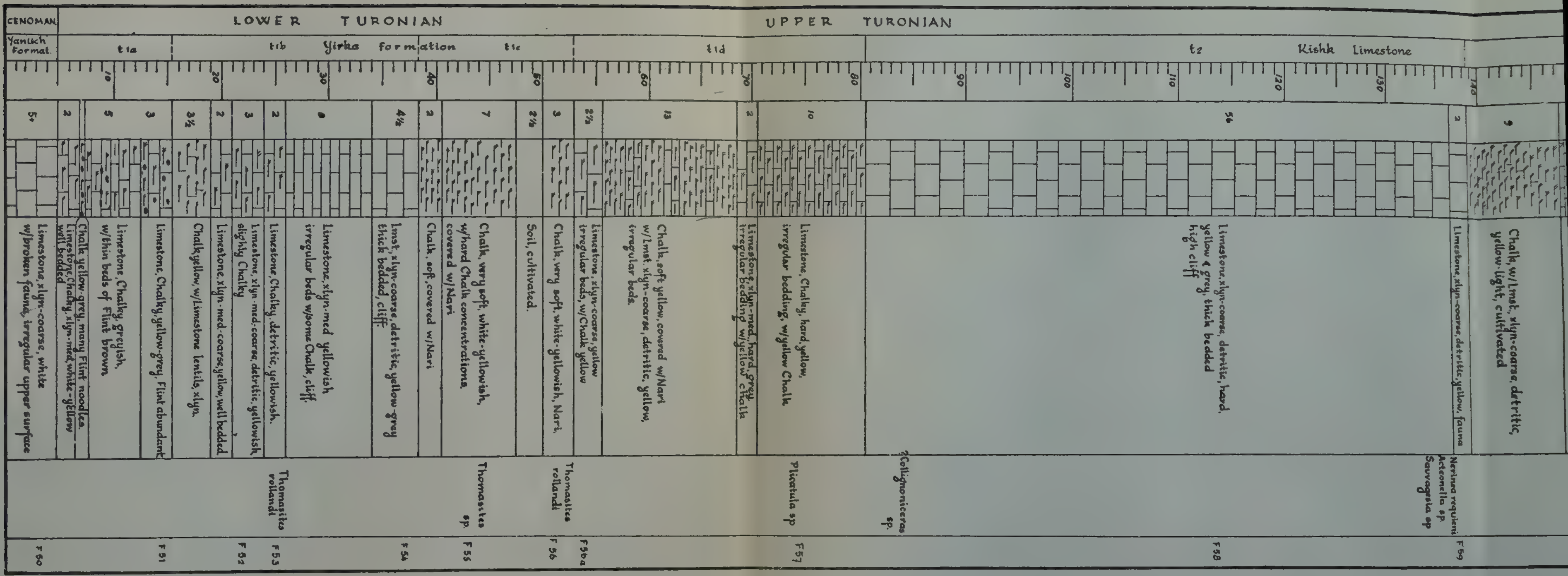
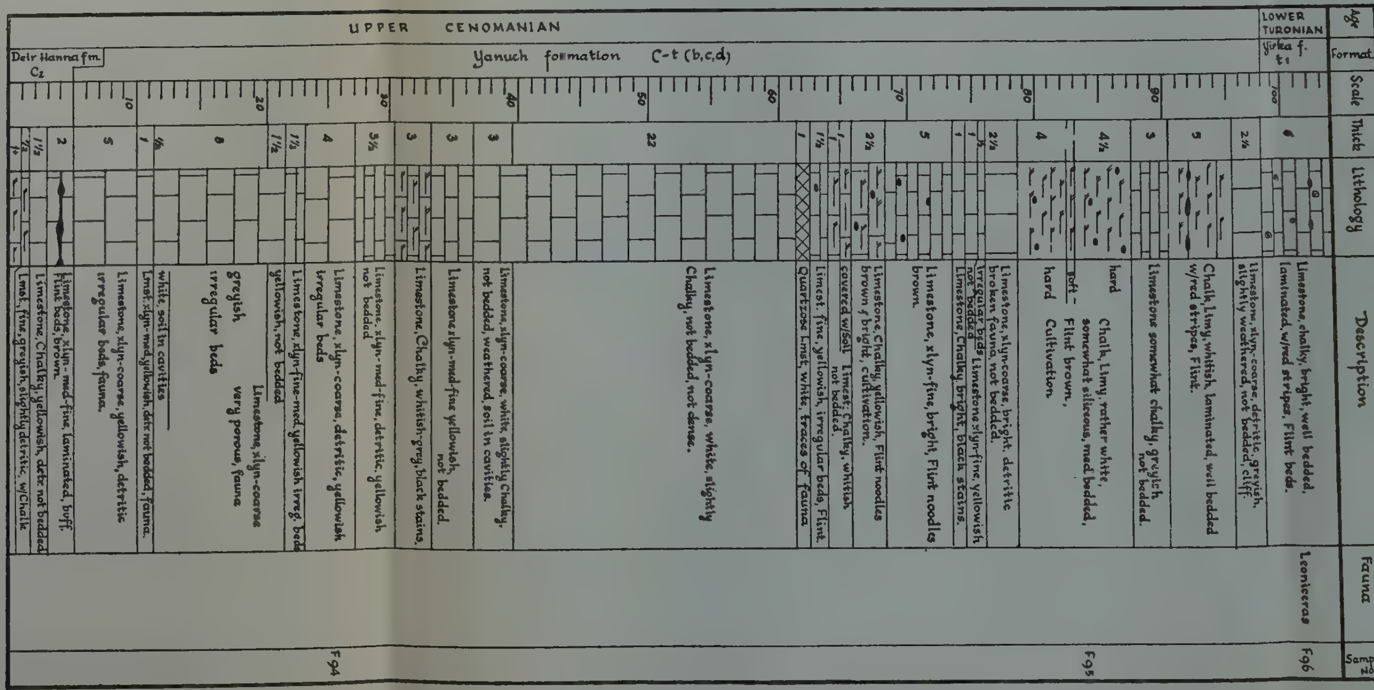
Outcrops map of Yirka Formation in Western Galilee




CENOMAN.
LOWER TURONIAN
UPPER TURONIAN
Yanuch Format.
t1a
t1b
Yirka formation
t1c
t1d
t2
Kishk Limestone


UPPER CENOMANIAN
LOWER TURONIAN
Deir Hanna fm. C2
Yanuch formation C-t (b,c,d)
Yirka f. t1
Age
Format.
Scale
Thick.
Lithology
Description
Fauna
Sample No.

ISRAEL GEOLOGICAL SOCIETY

PROCEEDINGS
SYMPOSIUM ON THE DEAD SEA AND SDOM REGION

Sdom, January 19–21, 1960

CONTENTS

* Presented but manuscript not submitted.
** Published in Hebrew in the *Bulletin of the Israel Geological Society*, no. 5, 1960.

ISRAEL GEOLOGICAL SOCIETY

Memorial meeting

G. S. BLAKE, 1876—1940

The Israel Geological Society has honoured the memory of the late GEORGE STANFIELD BLAKE, B. SC., A. R. S. M., F. G. S., M. I. M. M., Geological Adviser to the Mandatory Government of Palestine, by erecting a memorial plaque near the spot where he was so untimely killed 20 years ago. The plaque was unveiled during the annual general meeting of the Society held in Sdom, in the presence of H. M. Ambassador to the Government of Israel and other guests.

G. S. Blake was appointed Geological Adviser to the Palestine Government in 1922 and during the next 16 years, until his retirement in 1938, devoted himself to preparing a geological map of Palestine, besides advising on current problems of water supply and mineral prospecting. He travelled extensively all over the country to study its stratigraphy, building stones and mineral resources. The results of his investigations are summarized in comprehensive reports and detailed geological maps.

In 1940 he returned to Palestine to carry out a survey on behalf of the Palestine Mining Syndicate Ltd., and it was during this survey that he was murdered in the neighbourhood of Sdom.

Much of the geological work done since still rests on the sound foundations laid by Blake.

PUBLICATIONS CONCERNING PALESTINE BY G. S. BLAKE

1. *Geology and water resources of Palestine*, 1928, Govt. of Palestine, Printing and Stationery Office, Jerusalem, 51 pp. Map 1,000,000.
2. *The mineral resources of Palestine and Transjordan*, 1930, *Ibidem*, 41 pp.
3. *The stratigraphy of Palestine and its building stones*, 1935, *Ibidem*, 133 pp. Map 1: 1,000,000.
4. On the occurrence of marine Miocene in Palestine, 1935, *Geol. Mag.*, **72**, 140–142.
5. Old shore lines of Palestine, 1937, *Geol. Mag.*, **74**, 68–78.
6. *Geological map of Palestine* (*Northern part*), 1:100,000, 1937–39; handcoloured, unpublished.
7. *Geological map of Palestine*, (*Northern Sheet*). 1:250,000 1939, Govt. of Palestine, Jerusalem.
8. *A report on geology, soils and minerals and hydrogeological correlations of Transjordan*, *in* M. G. Ionides, 1940, *Report on the water resources of Transjordan and their development*, London.
9. *Geology and water resources of Palestine*, with M. J. Goldschmidt, 1947, Govt. of Palestine, Jerusalem, 413 pp.

The full text of a lecture by Prof. L. Picard on "*The life and work of G. S. Blake in Palestine*" delivered at the memorial meeting is to be published in Hebrew in the *Bulletin of the Israel Geological Society*, no. 5, 1960.

Contribution to the geology of the Mount Sdom area

ISRAEL ZAK, *The Geological Survey of Israel*

Mount Sdom is situated on the southwestern shore of the Dead Sea. It is elongat in N–S direction and rises abruptly to 250 m above the Dead Sea level. The morphol gy of Mount Sdom is characterized by sharp rugged features, steep walls and scar deep gorges, caves abutting in numerous vents and sinkholes.

The area has previously been investigated by many geologists, among them I Blanckenhorn, B. K. N. Wyllie, G. S. Blake, L. Picard, A. Vorman and Y. Bent

The present investigation was carried out in connection with the prospection potassium deposits. It was aided by chemical analyses, and the Cl/Br ratio w tested as a guide to stratigraphical and facies analysis.

Stratigraphy. The rocks of Mount Sdom are predominantly of lacustrine orig They also comprise several horizons of fluviatile conglomerates. The depos attain a thickness of several thousand metres and have accumulated during subsiden of the Arava Rift Valley and of the Dead Sea. The stratigraphic sequence — adapt and modified from Bentor and Vroman (1954 and in press) — is as follows:

5. Late Quaternary	—	Recent sediments Reg (hammada) Concretionary aragonitic beds and algal limestones Anhydrite
4. Lisan formation (L)	—	Marl, chalk, gravels, gypsum; partly varved; thickness o 60 m (on top of Mount Sdom only 25 m).
3. Anhydrite sequence (LH)	—	Anhydrite, clays, gypsum, dolomite, silt and sands; thickn 30 m.
2. Foothill formation (H)	—	Clays, silt, anhydrite; maximum thickness 700 m (known on top of Mount Sdom).
1. Sdom formation (SS, with sub-units SS_1–SS_4)	—	Rock salt, silt, sand, clay, anhydrite, laminated shales w fish and plant remains; exposed thickness over 400 m; Sdom I well, more than 1000 m.

Structure. Mount Sdom is a raised tilted block of complex structure. Its low part consists of rocks of the Sdom formation, the strata of which are strongly inclin 30°–50° to the west. Simple folds occur, which, however, do not disturb the continu of the layers. The rock salt is well bedded and there is no evidence of dissolution a recrystallization. Younger deposits of the anhydrite sequence and the Lisan formati form the top of the block. These layers are horizontal or slightly inclined.

The structure of Mount Sdom is difficult to explain on the basis of its exposu only. The views offered by various investigators are diverging and even contradicto The deep Sdom I well has shown that the roots of the mountain are much dee than assumed hitherto.

Potassium in the area of Mount Sdom. The object of the present survey was carry out a geochemical search for sources of potassium. The analyses of rocks a

waters of the area provided the following data: (a) Abundance of potassium in salt rocks: The general background values are up to 0.8% K^+. Anomalies of the order of 3–8% K^+ were detected. (b) Abundance of potassium in springs and in brine seepages: The general background values in the springs originating in the area (excluding those deriving from the Judean Mountains whose salinity is much lower) are up to 1 gram/litre K^+. Anomalies of the order of 15–30 gram/litre K^+ are found in the brine seepages and wells originating in Mount Sdom itself.

Average values of K^+, Na^+ and total salinity are (in gram/litre):

	Springs	*Brine seepages and wells*
K^+	1	20
Na^+	20	20
Total salinity	100	400

REFERENCES

1. Bentor, Y. K., and Vroman, A., 1954, The geological map of the Negev on a 1:100,000 scale, *Sheet* **16**: *Sdom*, 1st ed., (in Hebrew), Tel-Aviv; 2nd ed. (in press, in Hebrew and English), *Geol. Survey of Israel Pub.*, Jerusalem.

The oil shale deposits at Ein Boqeq

Yaacov Nir, *The Geological Survey of Israel*

The Ein Boqeq oil shale deposits are situated on the western shore of the Dead Sea, about 25 km north of the Dead Sea Works at Sdom. Outcrops of this oil shale are known to occur over a distance of about 3 km on the northern and southern sides of Nahal Boqeq (Wadi Feshet ed-Darawish), between the main fault escarpment and the Dead Sea shore.

Most of the geologists who worked in this area mentioned these oil shale outcrops in their reports, especially G. S. Blake and A. Vroman. Detailed prospection was started in 1951 when the Research Branch of the Defence Ministry initiated a series of borings in this area. Some of the laboratory and field work was then done by E. Gilav, S. Heller and F. Steckel of the Weizmann Institute of Science. The present investigation started at the end of 1954 and lasted nearly one year. It was sponsored by the Israel Mining Industries, Ltd.

The main object of these investigations was to establish the presence of about 5 million tons of oil shale ore, with an oil percentage of not less than 6.5%, which would be sufficient to build a small power plant using the crushed rock as fuel. Since the estimated reserves explored in the course of the investigations exceed 5 million tons, the programme was changed and the Israel Mining Industries laboratories are now investigating the feasibility of building a bigger power station than originally planned.

Regional Geology. The region is located on the western edge of the Dead Sea ri which abounds in drag faults. The enormous faulting displaced the shales at lea 400 to 500 m from their original position. Additional faulting underneath the Dea Sea appears likely.

The oil shales are of Senonian (Campanian) to Danian age, as based on determina tions of microfauna by Z. Reiss of the Geological Survey of Israel. The shales a covered unconformably over most of the area by the rocks of Lisan formation an Recent gravels and sometimes by the Hatseva formation.

Description of the deposit. As the deposit is situated on both sides of Nahal Boqe it has been divided into northern and southern fields. These fields were affected b the main rift faulting, and the throw of the northern field was much bigger than th of the southern one.

The fields are petrographically similar. The main rocks are limestone, dolomit marly and clayey limestone, containing organic matter and varying in colour fro light grey to brownish black.

Small percentage of phosphate is present throughout the section. Oil compris about one half of the total organic matter content of the rock. The oil content of t fields varies, but differences are largest in the thickness of the economic lay (over 6.5 % of oil). Its thickness averages 30 m in the southern as against 70 m in t nothern field.

The rocks throughout the sequence are very similar and could only be divid into three main members. A typical section is as follows:

Overburden: mainly Lisan marls and gravels, Recent gravels

— — — — — — — — — *Unconformity* — — — — — — — — — — — — — — —

Top oil shale: Weathered non-economic oil shales (thickness 4–6 m)
Medium oil shale: Economic oil shales (thickness 30 m South, 70 m North)
Bottom oil shale: Flinty and bituminous phosphate (thickness 2–10 m)

Campanian flint

Origin. Sedimentation took place in small basins under reducing conditions, that most of the organic matter putrafied without oxidation. Syngenetic pyr crystals and aggregates are considered as attesting to this type of environme The transition from oil shales to phosphate beds is gradual. It may therefore assumed that the depositional environment of the oil shales was in certain respe similar to the environment of deposition of phosphate.

On the fluctuations of the level of the Dead Sea

Cipora Klein, *Department of Geography, The Hebrew University of Jerusalem*

Based on the evidence obtained from photographs taken at various times of the prese century, and on the presence of long parallel lines of recent bars covered by dri wood, conclusions were drawn on the position of higher water level in the pa

The most convenient index for measuring the fluctuations of the level in past centuries is a tiny island in the northwestern corner of the Sea called Rujm el-Bahr, which has been surveyed and mapped by several observers. From this evidence and descriptions of many travellers, it was possible to reconstruct the changes of the Dead Sea level of the 19th century almost year by year, as summarized in the following:

1. From the end of the 18th century till 1807: shrinkage of level;
2. 1807–1829: very low level (about – 402 m);
3. 1830–1835: *sudden rise* of level to – 399 m, Rujm el-Bahr became a peninsula;
4. 1836–1861: higher steady level, frequent changes of Rujm el-Bahr from peninsula to island (–399.50 to – 397.50 m);
5. 1862–1874: slow rise of level, Rujm el-Bahr mostly isle (–399.50 to – 396 m);
6. 1875–1891: high steady level, Rujm el-Bahr an isle (–397.50 to – 395.50 m);
7. 1892–1897: *sudden rise* of level, Rujm el-Bahr wholly under water (–395 to – 391 m);
8. 1898–1932: very high level, Rujm el-Bahr covered by 3.75 m – 4.25 m thick layer of water;
9. 1933–1937: *rapid drop* of level, Rujm el-Bahr showing from waves (–391.50 to – 395.25 m);
10. 1938–1956: lower level, fairly steady, Rujm el-Bahr mostly under water (–394 to – 395.50 m);
11. 1957– *rapid drop* of level, almost one half of Rujm el-Bahr uncovered (–395 to –397 m).

Since in 1867 a drift-wood line was observed at 30 feet above the level of the lake (– 399.5 m according to Rojm el-Bahr), it was concluded that the Dead Sea level decreased by at least 9 m from the 18th century to 1867. It rose 11 m during the 19th century (–402 to –391 m) and fell 6 m during the first 60 years of the 20th century. Both the rises and drops of the level were abrupt: during the years 1933–1937, almost 4 m, and since 1957 another 2 m.

Traces of the two main levels in the 20th century are observable in the small lagoons at the height of –394 m between the recent bars, as well as on the two planes of abraded caves on the steep eastern marly slope of the Mor delta: –394.90 m and –393.10 m respectively.

The recent drop of level of the Dead Sea uncovered numerous conglomeratic bars, severely broken and ruined by the waves, which indicates that the lower levels of the Dead Sea occurred also quite frequently in the past.

However, the maximum range of fluctuations of the Dead Sea level in historical times did not exceed 16 m (i. e. – 402 m to – 387 m), as the lower outer wall of the Roman Boqeq fort is built at the –387 m level. The –386.36 m level marks also the top of a long, uninterrupted line of relatively recent bars on the north side of the Hever delta, rising above the big dry salt-lagoon which crowns the drift-wood covered recent bars.

Above the –386.36 m line, the mountain side is cut by several terraces, strongly eroded by numerous parallel little streams. These terraces are at the elevations of –383 m, –380.5 m, –387.61 m, –375.96 m, –373.41 m, and –368.96 m. The altitudes of these terraces perfectly correlate with those measured by Huntington in 1909 on the North-East coast of the Dead Sea, and by Butzer in 1955 on the North-West coast.

This correlation as well as the 15 m range of fluctuations of the level of the lake in historical times, the big deltas of the main streams and the tiny ones along

the steep slopes of the Judean Mountains on the western coast north of Engeddi all seem to indicate the unimportance of tectonic forces as compared with climatolo gical factors inducing the fluctuations of the level of the Dead Sea during historica times.

On the origin of the salts of the Dead Sea

S. Loewengart, *Mineral Engineering Department, Technion—Israel Institute o Technology, Haifa*

On the basis of estimates of total quantity of salts found in the Dead Sea and burie in the Rift Valley, divided by the estimated amount of airborne salts precipitate yearly over the present catchment area, it is calculated that only about 1 millio years would be necessary under today's conditions to accumulate all the salts.

Radioactive water sources at Sdom

Emanuel Mazor, *Israel Atomic Energy Commission*

During recent years a survey of the radium content of the water sources of the countr has been carried out. The results have shown that in the Rift Valley there exists number of springs with unusual radium concentrations, the highest values bein found in three cases near Sdom. The water brought up while drilling the Sdom I we contained 1000 $\mu\mu$g/l radium, and one of two small mineral springs on the eastern slop of Mount Sdom contained 705 $\mu\mu$g/l while normal water contains less than 2 $\mu\mu$g of radium and sources with 10 units are generally considered as unusual. Data fro other parts of the world show that concentrations of the order found at Sdom ar known only from sources connected with oil reservoirs or brines. Our observatio thus lead us to suggest that at Sdom too, such a buried reservoir exists. This hypothesi is supported by the following evidence: (1) The water is rich in potassium compound and other elements; (2) The water of Sdom I well contains an unusually hig amount of gas which has been found to contain about 20 % methane.

If the existence of such a buried "lake" rich in inorganic and carbonic compound will be proven, it will lead to the following conclusions:

a) In the Rift Valley there may exist additional buried reservoirs. From this poi of view a revised study of the Tiberias hot springs will have to be undertake as they have also an unusually high radium content (125 $\mu\mu$g/l) and are rich i other mineral compounds. Yet other reservoirs may exist that might be eve richer in organic compounds and it might be worthwhile to prospect these regio for oil and gas.

b) Radium analysis of the Dead Sea may enable to locate additional mineral spring at the bottom of the lake and thus help to explain its unusual composition. Indee in one sample of the Dead Sea water an anomalous amount of radium (62 $\mu\mu$gl

has been found which may indicate that near the sampling site such a spring does exist.

c) The Sdom water discussed here is economically rich in potassium. The finding of additional springs of the same character in the Dead Sea may prove that the reservoir is big enough for large scale exploitation.

The geochemical development of the Dead Sea

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The Dead Sea, situated in the deepest part of the Jordan-Arava Rift Valley, presents many unusual geochemical features. Its water has an extremely high salinity, and its chemical composition is unique. The area is highly arid, with an average annual rainfall of about 50 mm. Although scien tific observations on the Dead Sea have been carried out intermittently since the Lynch expedition first studied the area in 1948–49, a study of its Pleistocene and Recent sediments was begun only a short time ago. A considerable amount of data has become known through research in connection with the potash and bromine production from the water of the Dead Sea; through hydrogeological work on the Jordan River and its tributaties; though a study of the Pleistocene sediments of the Lisan Lake, as a result of a hydrological survey.

An analysis of the geological history of the area indicates that the Dead Sea is not a relict body of sea water and that its salts are the result of accumulation from closed continental drainage under arid conditions. They originate from two main sources, about one-third from the Jordan River and about two-thirds from highly saline springs discharging into the Dead Sea. On these facts a method can be based for calculating the age of the Dead Sea, leading to a maximum figure of about 70,000 years, and a minimum of 15,000 years, the latter being more probbale. The calculated total and annual amount of chemical precipitation in the Dead Sea is in agreement with observations that the sediment must consist of about equal amounts of aragonite, gypsum and halite.

The vast bromine reserves of the Dead Sea are neither of volcanic nor of organic origin and their derivation from fossil residual brines, formed during the Tertiary, is deemed probable.

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